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## **Neogene to Recent Species of *Krithe* (Crustacea: Ostracoda) from the Tasman Sea and off Southern Australia with Description of Five New Species**

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**ABSTRACT.** The ostracod genus *Krithe* is reported from four grab, two box-core, 62 coretop samples, and Neogene to Quaternary DSDP cores from the abyssal and bathyal regions of the Tasman Sea and off southern Australia. Species identification followed the taxonomic system proposed by Coles *et al.* (1994), in which the anterodorsal radial pore canals are of fundamental importance. A total of 19 species are recognised, five species are described as new: *K. comma*, *K. dilata*, *K. pseudocomma*, *K. prolata*, and *K. triangularis*. Fifteen species are referred to previously described species, and the remaining rare species are left in open nomenclature. Although no living specimens have been recovered, shells of all species have been found in modern sediments and are, therefore, considered to be extant. Overall, the stratigraphic distribution of the species demonstrates an increase in diversity from 3 to 19 species since the Early Miocene, with no extinction. The bathymetric range of most species is wide, though in certain species there are significant differences between the two study regions, such as on the Australian Continental Slope, the relatively much deeper occurrences of *K. triangularis* and *K. marialuisae*, and the absence of *K. dolichodeira* a species found commonly elsewhere. An explanation for such differences is most likely to relate to nutrient, substrate, and oceanographic differences between the two regions.

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The benthonic ostracod crustacean genus *Krithe* (Krithidae, Cytheracea, Podocopida) is abundant and widespread in the marine environment, absent only in shallow tropical waters. Despite its wide distribution, it is poorly documented in the Southwest Pacific. Perhaps the most notable study of species from this region is still the pioneering cruise report of the H.M.S. Challenger by Brady (1880). Subsequent studies have avoided identifying *Krithe* to species level, mainly because of the difficulty in classifying taxa with smooth external surfaces which offers few diagnostic characters, and additionally, internal soft-parts are rarely present for study.

Comprehensive studies of *Krithe* are limited mainly to the North Atlantic. The first of these (Peypouquet, 1975, 1977, 1979), reported considerable intraspecific variation, especially in the anterior vestibulum and carapace size. It was proposed that the anterior vestibulum size of different *Krithe* species is inversely proportional to the dissolved oxygen concentration at the sediment-water interface. That large and small vestibule types are often found in the same sample is dismissed by proponents of the hypothesis as inappropriate sampling: carapaces are an instantaneous record of environmental conditions, and that any one sample may include a number of seasonal morphotypes (Carbonel *et al.*, 1997). In recent years, the earlier claims have been challenged (Whatley & Zhao, 1993; van Harten, 1995, 1996) and the taxonomy has been extensively revised often resulting in further subdivision of previously designated species (Coles *et al.*, 1994). In our view, this alternative, more conservative concept of *Krithe* sets limits to intraspecific variation more consistent with that usually observed in species of other podocopid ostracod genera. Such methods have also been employed in other independent, contemporary studies (e.g., Abate *et al.*, 1993).

Biological data of *Krithe* is lacking, though significant observations on a living species, *Krithe praetexta praetexta*, from the Gullmar Fjord, Sweden, has been made in recent years (McKenzie *et al.*, 1989; Majoran & Agrenius, 1995; Agrenius *et al.*, 1997). Elofson (1941) reported an infaunal mode of life for that species, which has been confirmed by observations on living cultures; the species appears to live >1 cm in the sediment (Majoran & Agrenius, 1995). Careful box-core sampling in water depths up to 1,000 m, off California, has also revealed living specimens (rose bengal stained with intact soft-parts) of several species, present usually 1 cm below the sediment surface (Rathburn, 1998, pers. comm.). Given the similarity in carapace shape, such an infaunal mode of life might occur in all but perhaps the most rotund species of *Krithe*. Investigations into the hypothesis concerning the anterior vestibule size and oxygen content of the ambient seawater, in living populations, has been inconclusive (McKenzie *et al.*, 1989).

The purpose of the present study is twofold: (a) to describe new species of *Krithe* and document the distribution of all species collected during our extensive sampling of deep-sea sediments off New Zealand and southeast Australia. (b) To present the results of direct comparison of our Southwest Pacific material with Atlantic specimens of Coles *et al.* (1994), applying the anterodorsal radial pore canal (ADRPC) type system proposed by Coles *et al.* to initially identify the species.

**Material and methods.** Material for this study was taken from one grab, 68 coretop, and two box-core samples in the Tasman Sea and Continental Slope regions off southern Australia. Many of the cores also provided us with numerous samples of Quaternary age, dated largely by oxygen isotopic study of the cored sequence. In addition, we have included Pliocene and Pleistocene material from Deep Sea Drilling Project (DSDP) sites of the area, information embodied largely in an unpublished thesis completed during an extensive study programme, co-ordinated by one of us (RCW), investigating deep-sea Ostracoda of the Southwest Pacific (Ayress, 1988; Downing, 1985; Smith, 1983). Undocumented Tertiary material from DSDP sites 592–594 was also made available to us courtesy of Dr K. Swanson (University of Canterbury, New Zealand). Specimens from all nannofossil zones of the Neogene are well preserved and are considered in this study. Poor preservation or undocumented internal carapace features, prevented us from including available Palaeogene data. Table 1 lists details of the site localities (Fig. 1). Ostracod specimens were extracted from the sediment by immersing the samples overnight in a weak 3% solution of hydrogen peroxide and subsequently washing them through a 63 micron mesh sieve. Specimens obtained are disarticulated valves and occasional carapaces. No internal soft-part material was found.

All specimens have been deposited in the micro-palaeontological collections of the Geology Department Museum, Australian National University, Canberra. The catalogue numbers are prefixed ANU.

### Systematic palaeontology and comments on species distributions

**Krithidae** Mandelstam in Bubikyan, 1958

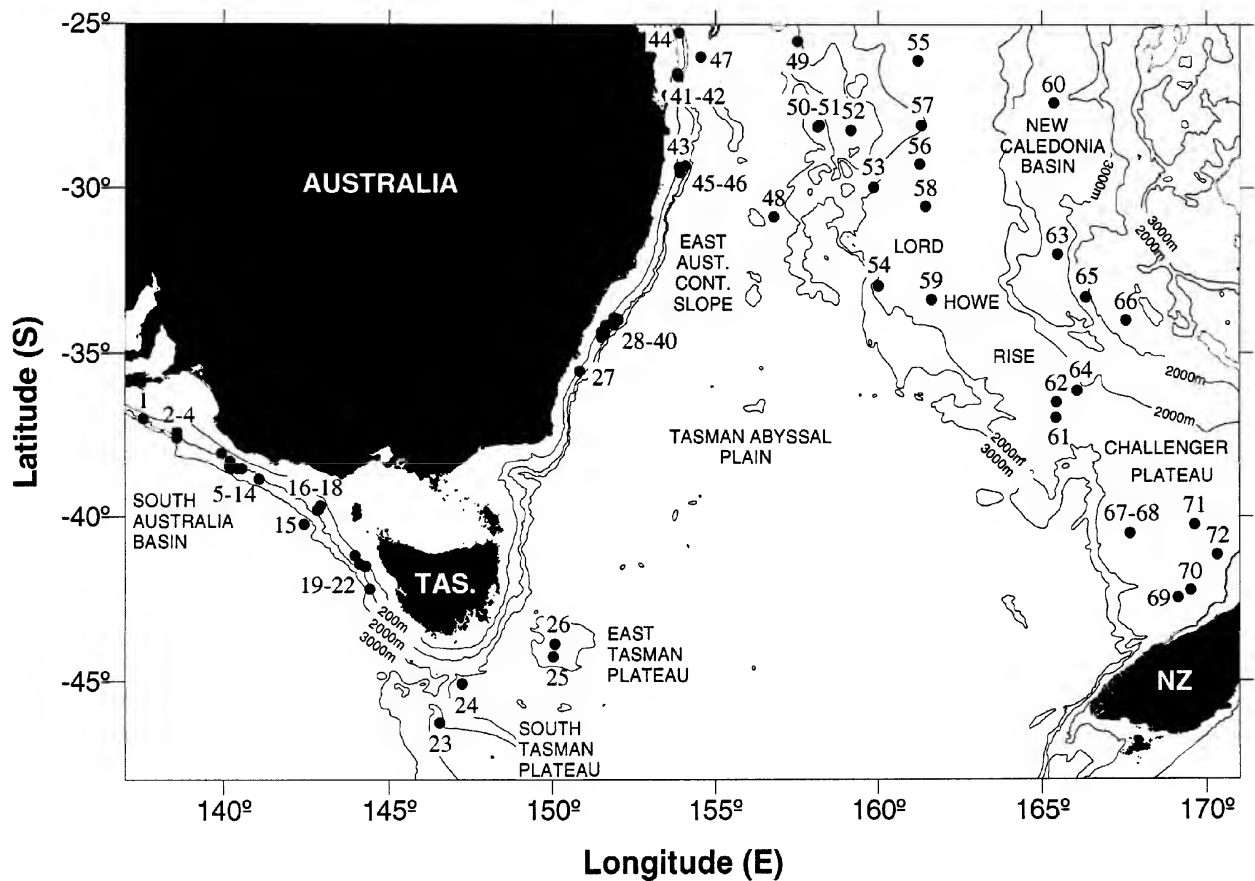
*Krithe* Brady, Crosskey & Robertson, 1874

Type species. *Ilyobates praetexta* Sars, 1866

**Discussion.** We found invaluable the system of initial identification based on the nature of the anterodorsal radial pore canals (ADRPC types) indicated by Coles *et al.* (1994), and the following species are ordered according to them. Coles *et al.* observed that, of the five radial pore canals (RPC's) in the anterodorsal region, within a species, one particular canal is much longer than the others. The ADRPC types are based on identifying which is the longest canal. Where the 3rd canal (counting away from the dorsal margin) is longest = type 1, the 2nd canal longest = type 2, the 4th canal longest = type 3. See Fig. 2 and Coles *et al.* (1994, text-figure 1) for additional explanation of terminology.

Further subdivision of the categories was proposed where canals are short, missing, or present as a normal pore. Since the width of the fused zone can vary, short ADRPC's may be present as a normal pore close to the inner margin. It follows that in order to recognise natural groupings, normal pore canals (NPC's) should be considered in ADRPC type recognition where they vary intraspecifically from NPC to RPC, or where they can be shown to be homologous with RPC's in other species. For example, in *Krithe reversa*, AD 2 (the canal immediately below the dorsal-most anterodorsal radial pore canal) is considered by Coles *et al.* (1994) to be





**Figure 1.** Distribution of sites considered in this report. See Table 1 for map code numbers.

present as a normal pore close to the inner margin. Therefore, the species has ADRPC type 1, rather than type 2, a designation if one was to ignore the normal pore in question.

For this reason, we take great care in illustrating normal pores close to the inner margin. We are less confident that the subdivisional groupings of the ADRPC types can be recognised consistently for the following reasons. (a) The width of the fused zone shows significant variability. (b) NPC's close to the inner margin can be confused with false

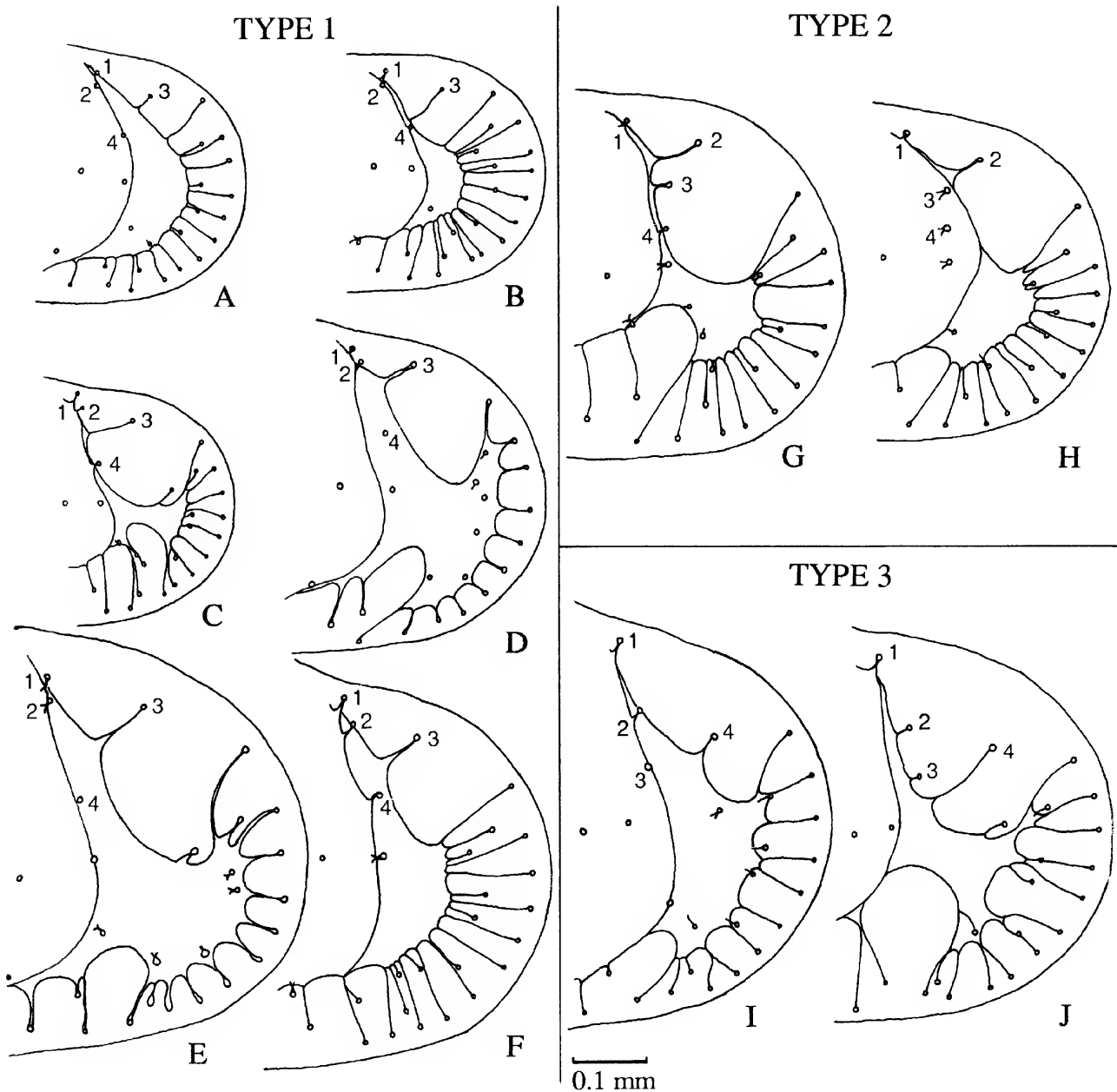
RPC's when the shell is very thick, translucent, or strongly inflated, causing oblique viewing of the canal. (c) Removal of obscuring sediment retained in the narrow zone between the line of concrescence and the inner margin anterodorsally can be difficult.

The following abbreviations are used: A = adult, LV = left valve, RV = right valve, AD = anterodorsal, RPC = radial pore canal, ADRPC = anterodorsal radial pore canal, NPC = normal pore canal.

#### Key to Southwest Pacific *Krithe* species

- |   |   |                   |
|---|---|-------------------|
| 1 | Anterodorsal radial pore canal pattern of Type 1 (AD 3 longest) ..... | 2                 |
| — | Anterodorsal radial pore canal pattern of Type 2 (AD 2 longest) ..... | 10                |
| — | Anterodorsal radial pore canal pattern of Type 3 (AD 4 longest) ..... | 14                |
| 2 | Left valve overlaps right valve .....                                 | 3                 |
| — | Right valve overlaps left valve .....                                 | <i>K. reversa</i> |
| 3 | Large (length usually greater than 1 mm) .....                        | 4                 |
| — | Medium to small (length usually less than 1 mm) .....                 | 5                 |

- 4 Dorsal margin strongly convex; lateral outline triangular ..... *K. triangularis*
- Lateral outline subrectangular to subrhomboidal ..... *K. dolichodeira*
- 5 Anterior vestibulum semicircular in lateral outline ..... 6
- Anterior vestibulum mushroom or hook-shaped ..... 7
- 6 Medium sized, moderately well inflated ..... *K. antisawanensis*
- Small, compressed, usually with long, straight RPC's ..... *K. compressa*
- 7 Anterior vestibulum narrow and upward curved ..... 8
- Anterior vestibulum mushroom-shaped ..... 9
- 8 Anterior vestibulum very narrow; posterodorsal inner lamella  
wide ..... *K. minima*
- Anterior RPC's often branching; posterodorsal inner lamella  
moderately narrow ..... *K. marialuisae*
- 9 Carapace moderately well inflated, muscle scars small and  
undivided ..... *K. posticliva*
- Carapace weakly inflated; muscle scars long, uppermost scar  
subdivided ..... *Krithe* sp. 1
- 10 Carapace small, anterior vestibulum small ..... 11
- Carapace medium to large sized and subrectangular ..... 12
- Carapace very large and tumid ..... *Krithe* sp. 2
- 11 Anterior vestibulum bilobed ..... *K. droogeri*
- Anterior vestibulum at mid-height and elongate ..... *K. perpulchra*
- 12 Lateral outline subovate; strongly sexually dimorphic; uppermost  
adductor muscle scar a reclined "F" shape ..... *K. prolata*
- Outline subrectangular; uppermost adductor muscle scar "U"  
shaped ..... *K. dilata*
- Outline subrectangular; uppermost adductor muscle scar  
subdivided ..... 13
- 13 Carapace weakly inflated; males strongly sloped dorsally; anterior  
vestibulum mushroom-shaped ..... *K. comma*
- Carapace moderately well inflated; sexual dimorphism slight;  
anterior vestibulum strongly downturned ..... *K. pseudocomma*
- 14 Carapace very small; anterior RPC's long ..... *K. pernoides sinuosa*
- Carapace medium to large (length usually less than 1 mm); anterior  
vestibulum mushroom-shaped ..... *K. morkhoveni morkhoveni*
- Carapace very large (length usually greater than 1 mm); anterior  
vestibulum "T" shaped ..... *K. trinidadensis*



**Figure 2.** Recognition of the three patterns of anterodorsal radial pore canals (ADRPC types), illustrated by camera lucida drawings of internal valve features. All figures are external views. Anterodorsal radial pore canals or homologous normal pore canals, are numbered 1–4. The three patterns are defined most readily by identifying which of the canals, 1–3 in the anterodorsal region, is the longest. Type 1, canal 3 is longest, shown for example in A, B (*K. compressa*, expanded vestibule form, female RV, ANU 57036, and male RV, ANU 57038, respectively), C (*K. minima*, female RV, ANU 57052), D (*K. dolichodeira* female RV, ANU 57044), E (*K. triangularis*, expanded vestibule form, male LV, ANU 57011, image inverted for ease of comparison), and F (*K. reversa* female LV, ANU 57034, image inverted for ease of comparison). Note that canal 2 is usually a normal pore close to canal 1. It occurs as a short radial pore canal where the fused zone is wide, see C (see also *K. reversa* illustrated by Coles *et al.*, 1994, text-fig. 3D). Canal 4 is always a normal pore. Type 2, canal 2 is longest, and probably homologous to the normal pore close to canal 1 of Type 1 species (the normal pore is absent in Type 2 species); shown for example in G and H (*K. comma*, male RV, ANU 57023, and expanded vestibulum form of male RV, ANU 57026, respectively). Note that where the fused zone is narrow canal 3 is a normal pore, H, and canal 4 is always a normal pore. Type 3, canal 4 is longest, shown for example in I and J (*K. trinidadensis*, expanded vestibulum form, female RV, ANU 57075, and male RV, ANU 57078, respectively). Note that where the fused zone is narrow canals 2 and 3 are normal pores, see I.

## ADRPC TYPE 1

*Krithe compressa* (Seguenza, 1880)

Figs. 2A,B, 3A–D, 8A,B

*Ilyobates compressa* Seguenza, 1880: 325; pl. 17, figs. 30, 30a.  
*Krithe aequabilis* Ciampo, 1986: 87; pl. 17, figs. 1, 2.—Coles, Whatley & Moguilevsky, 1994: 78; pl. 1, figs. 7–12; text-fig. 3E–K.  
*Krithe compressa* (Seguenza).—Ruggieri, 1991: 60, figs. 5–7.—  
 Abate, Barra, Aiello & Bonaduce, 1993: 354; pl. 3, figs. 1–5; pl. 17, figs. 1, 2.  
*Krithe* sp. 5 Whatley & Zhau, 1993: fig. 3.8.

**Remarks.** We concur with Abate *et al.* (1993) that *K. compressa* is a senior synonym of *K. aequabilis* Ciampo, 1986. In overall shape it is very similar to *K. marialuisae* Abate *et al.* described from the Plio-Pleistocene of Sicily. However, the anterior vestibule of *K. compressa*, although variable in shape, is usually less upturned than it is in *K. marialuisae*, and the radial pore canals do not bifurcate as they do in the latter species. In addition, *K. compressa* can be distinguished from *K. marialuisae* by its weaker inflation. Both species are common in our material.

The width of the anterior fused zone varies somewhat, and the normal pore close to AD 1 sometimes becomes a short AD 2 (Coles *et al.*, 1994). In species which have ADRPC of type 2 there is no normal pore in this position but instead a long RPC is present. For this reason we suggest that the normal pore is homologous to AD 2 in other species. Therefore, to maintain natural relationships of the ADRPC system, we include the normal pore when counting ADRPC's. Thus, we assign this species to an ADRPC category of type 1B.

**Distribution.** Occurs widely throughout the study region at water depths from 759 to 3281 m.

**Stratigraphical range.** Late Miocene (NN 11a) to Recent, based on core records of DSDP sites 208, 284, 592 and 593.

*Krithe antisawanensis* Ishizaki, 1966

Figs. 3E,F, 8C,D

*Krithe antisawanense* [sic] Ishizaki, 1966: 137, pl. 18, figs. 17, 24, 25.—Zhau, 1988: 243, pl. 42, figs. 1, 2.—Zhou & Ikeya, 1992: 1111, figs. 9.4, 9.5.

**Remarks.** This species appears to be identical to *K. reversa* Bold except in having normal overlap (Ishizaki, 1966). Like *K. reversa* there is a normal pore close to AD 1 homologous to AD 2.

**Distribution.** This is the most widespread species of this study, ranging in depth from 686 to 3403 m.

**Stratigraphical range.** Middle Miocene (NN 6) to Recent, based on core records of DSDP sites 206, 207, 208, 284, 592 and 593.

*Krithe dolichodeira* Bold, 1946

Figs. 2D, 3G,H, 8E,F

For comprehensive pre-1988 synonymy see Coles *et al.* (1994)

*Krithe dolichodeira* Bold, 1946: 75, pl. 4, figs. 14a,b.—Coles, Whatley & Moguilevsky, 1994: 81; pl. 1, figs. 13–18; text-fig. 3L–Q.  
*Parakrithe hemideclivata* Ruan in Ruan & Hao, 1988: 272, pl. 45, figs. 12–15.  
*Krithe spatularis* Dingle, Lord & Boomer, 1990: 272, figs. 16D–F, 17B, 18E.  
*Krithe hemideclivata* (Ruan).—Whatley & Zhau, 1993: fig. 3.9.

**Remarks.** The characteristic mushroom shaped anterior vestibulum varies in our material, particularly in the width of the neck and dorsally. In this regard, and also in the lateral outline, our material is very close to an Atlantic species illustrated by Coles *et al.* (1994, text-fig 3AA–DD) as *Krithe* sp. cf. *K. hiwanneensis* (Howe & Law). However, our material is much larger than that species. In size it closely matches those specimens examined by Dingle *et al.* (1990) (named *K. spatularis*) from off South Africa, and also Quaternary specimens cited by Coles *et al.* (1994: 81). This is to be expected given the relatively young age of our material.

**Distribution.** Recorded in our study region at depths from 686 to 3281 m, only in the eastern and northern parts of the Tasman Sea.

**Stratigraphical range.** Late Miocene (NN 11b) to Recent, based on core records of DSDP sites 206, 207, 208, 284, 592 and 593. The species is also known to occur much earlier from the Early Eocene zone NP 10 (Coles *et al.*, 1994).

*Krithe marialuisae*

Abate, Barra, Aiello &amp; Bonaduce, 1993

Figs. 3I,J, 8G,H

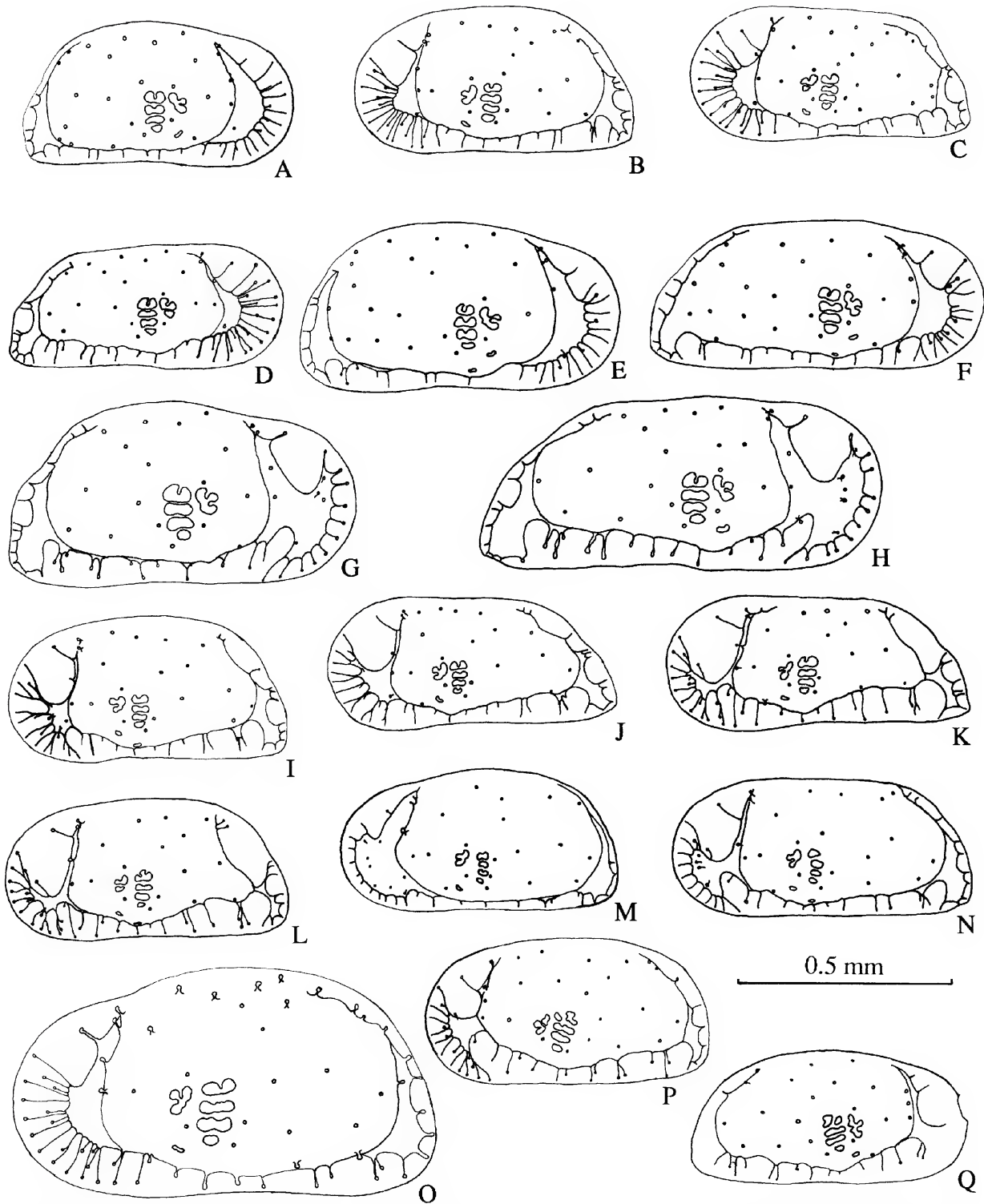
*Krithe* sp. 3 Ciampo, 1980: 17; pl. 4, fig. 4.  
*Krithe marialuisae* Abate, Barra, Aiello & Bonaduce, 1993: 361; pl. 2, figs. 1–5; pl. 6, fig. 5.

**Remarks.** The Sicilian material described by Abate *et al.* (1993) is somewhat smaller (length of holotype 0.58 mm), but in all other respects our material appears to conform to this species. It is similar to *Krithe sphaenoidea* Ruan (in Ruan & Hao, 1988), from the Okinawa Trough. However, judging from the illustrations given, that species appears to have a more convex ventral margin and straighter anterior RPC's.

**Distribution.** The species is distributed throughout the study region, ranging in depth from 1066 to 2860 m.

**Stratigraphical range.** Middle Miocene (NN 7) to Recent, based on core records of DSDP sites 207, 208, 284, 592 and 593.





**Figure 3.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A–D, *Krithe compressa* Seguenza, A, female right valve (ANU 57036), 71GC44, 100 cm, B, female left valve (ANU 57035), SO-36-61, 157 cm, C, male left valve (ANU 57037), 71GC44, 15 cm, Holocene, D, male right valve (ANU 57038), 71GC44, 15 cm, Holocene; E–F, *Krithe antisawanensis* Ishizaki, E, female right valve (ANU 57040), 67GC03, 274 cm, F, male right valve (ANU 57042), 67GC03, 280 cm; G, H, *Krithe dolichodeira* Bold, G, female right valve (ANU 57044), SO-36-61, 144.5 cm, H, male right valve (ANU 57046), SO-36-61, 157 cm; I, J, *Krithe marialuisae* Abate *et al.*, I, female left valve (ANU 57047), 1/86 6GC3, 125 cm, J, male left valve (ANU 57049), SO-36-61, 144.5 cm; K, L, *Krithe minima* Coles *et al.*, K, male left valve (ANU 57053), SO-36-61, 117 cm, L, female left valve (ANU 57051), SO-36-61, 148.5 cm; M, N, *Krithe posticlivia* Hao, M, female left valve (ANU 57055), 71GC44, 15 cm, N, male left valve (ANU 57057), 71GC26, 15 cm; O, *Krithe reversa* Bold, female left valve (ANU 57034), 71GC26, 22 cm; P, Q, *Krithe* sp. 1, P, female? left valve (ANU 57017), 105GC20, coretop, Q, female? right valve (ANU 57018), 105GC20, coretop.

***Krithe minima***

Coles, Whatley & Mognilevsky, 1994

Figs. 2C, 3K,L, 8I,J

*Krithe minima* Coles, Whatley & Mognilevsky, 1994: 88; pl. 2, figs. 16–18; pl. 3, figs. 1–5; text-fig. 3EE–JJ.

**Remarks.** The species is distinct by virtue of its relatively small size, very narrow crescentic anterior vestibule, and wide posterodorsal inner lamella. In our material there are two short anterodorsal radial pore canals (AD 1 and AD 2), AD 2 sometimes being present as a normal pore. Thus, the elongate radial pore is AD 3 indicative of ADRPC Type 1A, and 1B where AD 2 is a normal pore.

**Distribution.** Found at water depths of 1066 to 3281 m in the Tasman Sea.

**Stratigraphical range.** Early Miocene (NN 1) to Recent, based on core records of DSDP sites 206, 207, 208, 284, 592 and 593. The species is very common throughout the Neogene.

***Krithe posticliva*** (Hao in Ruan & Hao, 1988)

Figs. 3M,N, 8K,L

*Parakrithella posticliva* Hao in Ruan & Hao, 1988: 273, pl. 45, figs. 8–11.—Ruan, 1989: 121, pl. 22, figs. 14, 15.

**Remarks.** The mushroom-shaped anterior vestibulum of this species is sometimes greatly expanded proximally. *Krithe posticliva* is similar to *Krithe exigua* and *K. marialuisae*, both described from the Plio-Pleistocene of Sicily by Abate *et al.* (1993). However, *K. posticliva* differs from both species in its more truncate posterior margin and is more elongate.

**Distribution.** The species is rare in our study, found only on the eastern Australian continental slope from 989 to 1989 m.

**Stratigraphical range.** Late Pliocene (NN 16) to Recent, based on core records of DSDP site 593.

***Krithe reversa*** Bold, 1958

Figs. 2F, 3 O, 8M

For comprehensive pre-1988 synonymy see Coles *et al.* (1994).

*Krithe reversa* Bold, 1958: 404, pl. 1, figs. 4a–g.—Coles, Whatley & Mognilevsky, 1994: 77; pl. 1, figs. 1–6; text-fig. 3A–D.

*Krithe tumida* Nohara, Itose & Tabuki, 1988: pl. 2, fig. 1.

*Krithe sawanensis* Hanai, 1959.—Ruan & Hao, 1988: 269; pl. 40, figs. 21–23; pl. 44, figs. 11–17.—Ruan, 1989: 121, pl. 22, fig. 12.—Whatley & Zhao, 1993: figs. 2, 3.—Zhou & Ikeya, 1992: 1108, fig. 3 (uppermost), fig. 7 (lower), figs. 9.1–9.3, figs. 10.1–10.3.

*Krithe* sp. 4 Dingle, Lord & Boomer, 1990: 282, figs. 17D, 18F, 22E.

**Distribution.** This species is not common, but is widely distributed, occurring at almost all sites in our study region. It was found at depths from 850 to 3552 m.

**Stratigraphical range.** Early Pliocene (NN 13) to Recent, based on core records of DSDP sites 206, 208 and 284. The earliest known record of the species is Middle Miocene zone NN 6 (Coles *et al.*, 1994).

***Krithe triangularis* n.sp.**

Figs. 2E, 4A–H, 8N,O

*Krithe* sp. 14 Coles, Whatley & Mognilevsky, 1994: text-fig. 6T,U.

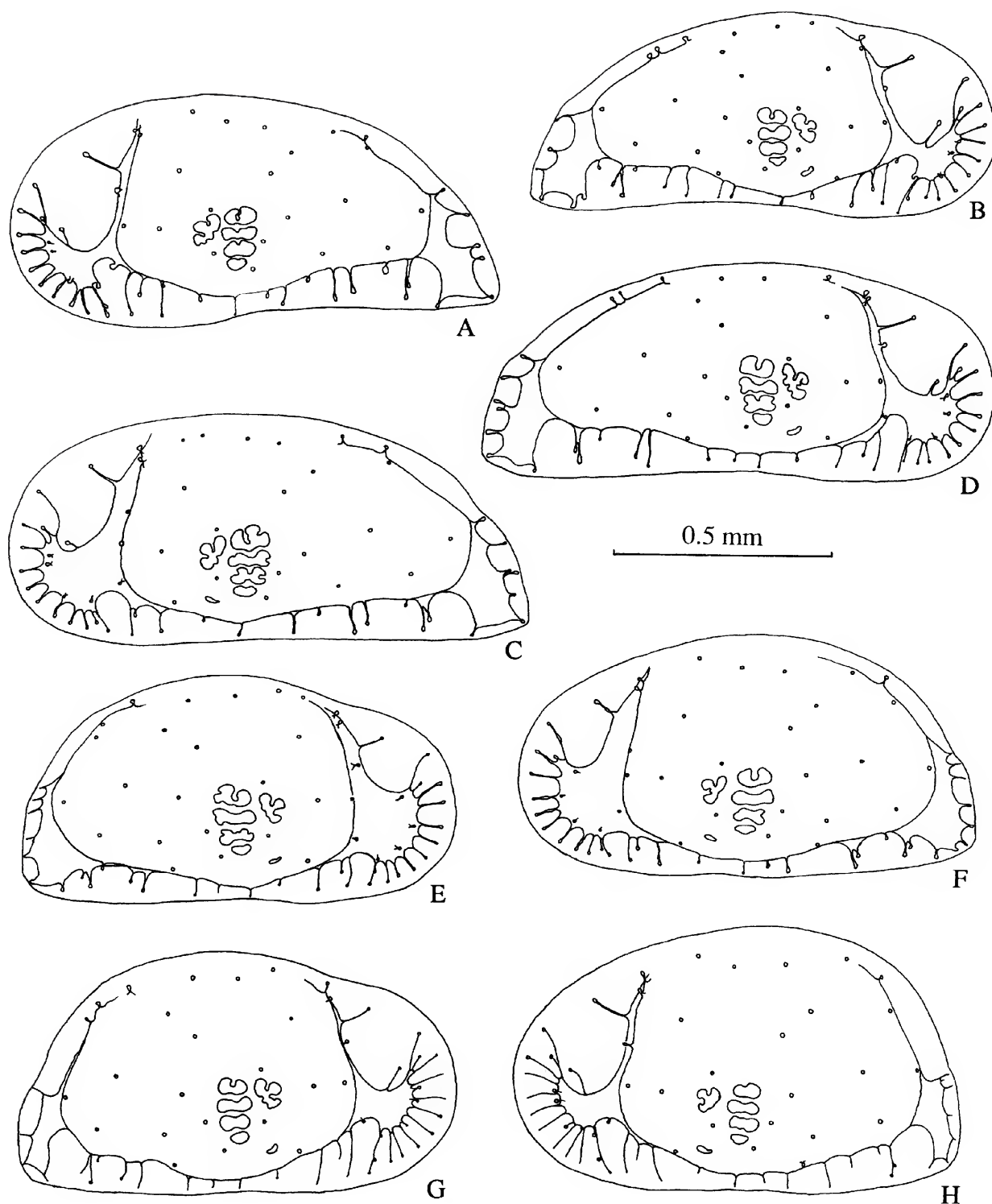
**Etymology.** Latin, triangular. Referring to the triangular lateral outline especially of males of this species.

**Type material and dimensions.** HOLOTYPE, ANU 57011, male LV, length 1.26 mm, height 0.58 mm. PARATYPES: ANU 57012, male RV, length 1.24 mm, height 0.55 mm, core SO-36-61, interval 37 cm; ANU 57013, female LV, length 1.12 mm, height 0.61 mm, core SO-36-61, interval 157 cm; ANU 57014, female RV, length 1.08 mm, height 0.57 mm, core SO-36-61, interval 157 cm; ANU 57015, female LV, length 1.12 mm, height 0.66 mm, core 71GC026, interval 60 cm. All specimens are of Late Pleistocene age.

**Type locality and horizon.** Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne core 36-61, interval 69 cm, Late Pleistocene.

**Diagnosis.** A very large species of *Krithe* with pronounced sexual dimorphism. Males subrectangular to subtriangular in lateral view, with dorsal margin gently convex throughout shell length; females are much shorter and less tapering posteriorly. Inner lamella is narrow posterodorsally, wide posteroventrally with a large posterior vestibulum. The anterior vestibulum is large and mushroom-shaped with variable neck width. ADRPC of type 1B.

**Description.** Carapace large, strongly sexually dimorphic: in lateral outline males are subtriangular to subrectangular, females rectangular and considerably shorter. Dorsal margin in both sexes is gently convex throughout, except in RV which has a slight concavity at anterior third of length. In males the dorsal margin tapers to an acute posteroventral angle interrupted by a distinct mid-posterior shoulder. In females the posterior is more truncate. Ventral margin usually straight in females, gently to strongly concave in males. Normal overlap. Inner lamella narrow dorsally and mid ventrally, wide elsewhere. Anterior vestibulum is large and mushroom-shaped with variable neck width; dorsal lobe usually more strongly developed than ventral lobe. ARPC's are short to moderately long. ADRPC of type 1B. AD 1 and 2 are closely adjacent. AD 1, 2 and 4 are normal pores, which are situated, when viewing valve in lateral aspect, usually between line of concrescence and inner margin, or rarely just behind inner margin. Posterior vestibulum is deep with wide neck. Muscle scars large, often with very meandering outlines but are not subdivided.



**Figure 4.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A–H, *Krithe triangularis* n.sp., A, male left valve (P. Smith M.Sc collection, UC Aberystwyth), 208/3/3, late Pliocene, B, male right valve (P. Smith M.Sc collection, UC Aberystwyth), 208/3/3, late Pliocene, C, male left valve (holotype, ANU 57011), SO-36-61, 69 cm, D, male right valve (ANU 57012), SO-36-61, 37 cm, E, female right valve (ANU 57014), SO-36-61, 157 cm, F, female left valve (ANU 57013), SO-36-61, 157 cm, G, female right valve of carapace (ANU 57015), 71GC26, 60 cm, H, female left valve of carapace (ANU 57015), 71GC26, 60 cm.

**Remarks.** Males of *K. triangularis* show considerable variation in the degree of posterior acumination. Weakly acuminate forms and females can be confused with *K. antisawanensis*. However, *K. triangularis* can be distinguished easily from that species in its mushroom-shaped anterior vestibulum and larger carapace.

**Distribution.** Widely distributed particularly in the East Tasman Sea, where it occurs at depths from 1125 to 3281 m. The species is somewhat deeper, ranging no shallower than 1818 m, on the Australian Continental Slope (Table 1).

**Stratigraphical range.** Early Miocene (NN 1) to Recent, based on core records of DSDP sites 207, 208, 284, 592 and 593. The species is very rare in the Late Miocene.

### *Krithe* sp. 1

Figs. 3P,Q, 8P

**Description.** Carapace very small and weakly inflated. Lateral outline subrectangular; sexes not apparent. Dorsal margin gently convex throughout, except in RV which has a slight concavity at anterior quarter of length. Posterior margin convex dorsally, truncate ventrally with mid-posterior shoulder almost indistinct. Ventral margin is straight. Normal overlap. Inner lamella narrow postero-dorsally moderately wide elsewhere. Anterior vestibulum mushroom-shaped, weakly expanded distally, and with a moderately narrow neck. ARPC's are moderately long. ADRPC of type 1B. AD 2 and 4 are normal pores. Posterior vestibulum narrow. Adductor muscle scars large except for the lowermost scar which is much smaller; the uppermost scar is subdivided into two. Frontal scar trefoil, sometimes subdivided.

**Remarks.** The species is distinct by virtue of its very small size and weak inflation. It is left in open nomenclature due to the paucity of material.

**Distribution.** Found only at 355 m on the eastern Australian continental slope. A single specimen has also been found in the Early Pleistocene of DSDP site 284.

### ADRPC TYPE 2

#### *Krithe droogeri* Keij, 1953

Figs. 5A,B, 8Q

*Krithe droogeri* Keij, 1953: 159, pl. 1, figs. 6a,b, 7.—Ruan & Hao, 1988: 269, pl. 44, figs. 1, 2.

*Krithe* sp. cf. *K. droogeri* Keij.—Whatley & Zhao, 1993: 288, fig. 3.14.

**Remarks.** The species is very distinctive by virtue of its small bilobed anterior vestibulum and branching radial pore canals. There is some variation in lateral outline: the dorsal margin is arched in our specimens, but in the China Sea,

specimens illustrated by Ruan & Hao (1988) and Whatley & Zhao (1993) it is straight. Sexual dimorphism may explain these differences. Although we found too few specimens to distinguish the sexes in our material, the convex dorsal margin suggests that they are all female.

**Distribution.** Found between 1200 and 1989 m on the eastern Australian continental slope.

**Stratigraphical range.** The species is very rare and found sporadically from the Middle Miocene (NN 6) to Recent. The fossil occurrences are from DSDP cores 206 and 592.

#### *Krithe perpulchra*

Abate, Barra, Aiello & Bonaduce, 1993

Figs. 5C–E, 8R

*Krithe perpulchra* Abate, Barra, Aiello & Bonaduce, 1993: 364; pl. 3, figs. 6–9; pl. 6, fig. 13.

**Remarks.** Very few specimens of this species were found and of those only females were well preserved. Although Abate *et al.* (1993) illustrate and describe only males, our specimens clearly show the anteriorly tapering anterior vestibulum characteristic of this species.

**Distribution.** Found at 759 m, 773 m and, probably transported (single poorly preserved male specimen) at 1321 m off eastern Australia.

**Stratigraphical range.** Late Pleistocene (NN 21) to Recent, based on numerous piston core records from the Australian Continental Slope. The earliest known occurrence of this species is Pliocene Zone M Pl 4 of Sicily (Abate *et al.*, 1993).

#### *Krithe prolata* n.sp.

Figs. 5F–I, 8S,T

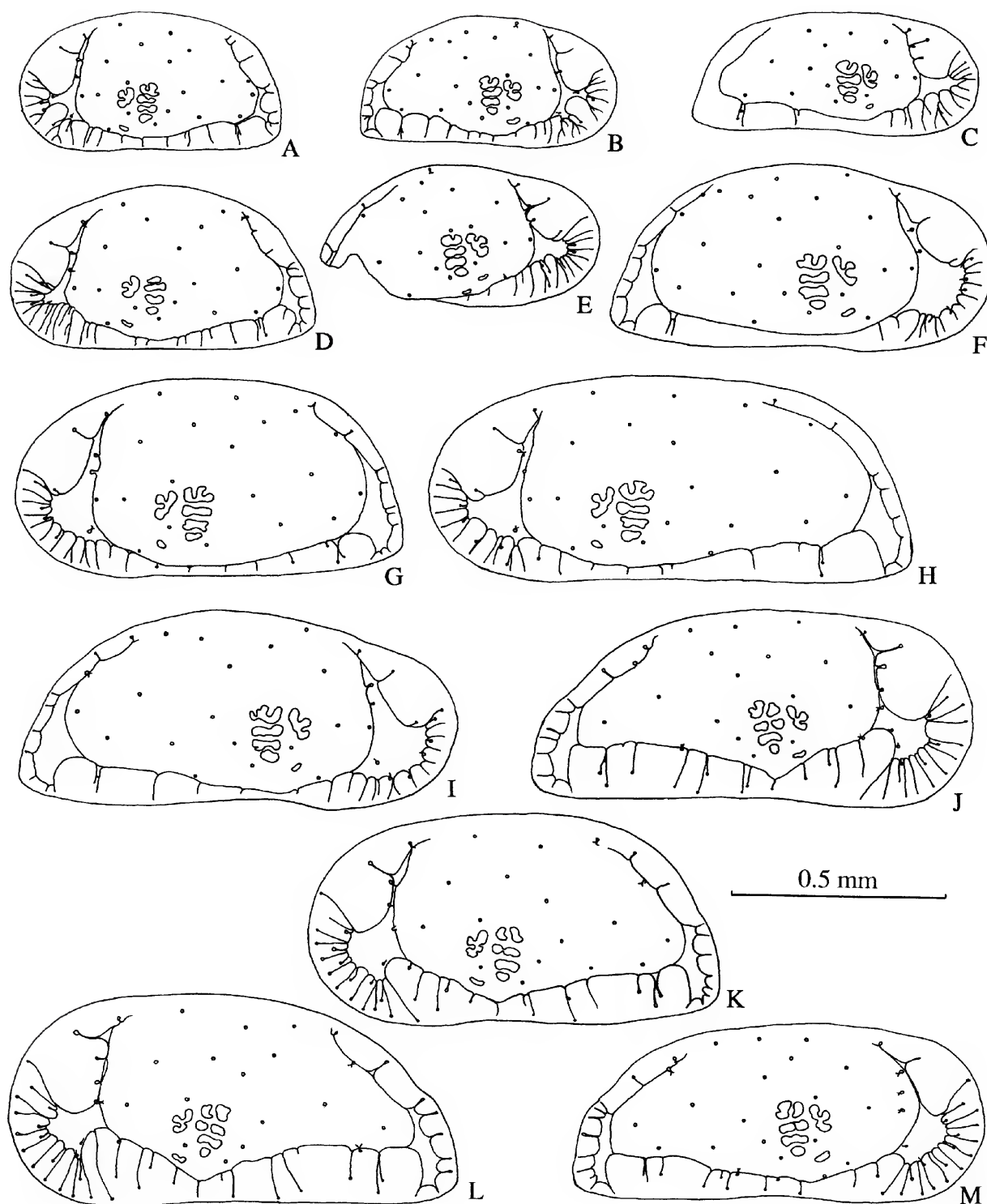
? *Krithe* sp. Guernet, 1993: 348, pl. 1, fig. 10.

**Etymology.** Latin, elongated. Referring to the elongate shape of this species.

**Type material and dimensions.** HOLOTYPE, ANU 57019, male LV, length 1.21 mm, height 0.52 mm. PARATYPES: ANU 57020, male RV, length 1.12 mm, height 0.50 mm, core 67GC03, interval 56 cm; ANU 57021, female LV, length 0.99 mm, height 0.51 mm, core 67GC03, interval 56 cm; ANU 57022, female RV, length 0.96 mm, height 0.47 mm, core 67GC03, interval 7 cm. All specimens are Late Pleistocene in age.

**Type locality and horizon.** Continental slope off southeastern Australia, present day water depth 1476 m, AGSO core 67GC03, interval 7 cm, Holocene.





**Figure 5.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A, B, *Krithe droogeri* Keij, A, female left valve (ANU 57059), 71GC44, 15 cm, Holocene, B, female right valve (ANU 57060), 71GC44, 15 cm, Holocene; C–E, *Krithe perpulchra* Abate *et al.*, C, male right valve (ANU 57063), 71GC44, 160 cm, D, female left valve (ANU 57061), 5/91 40Pc10A, coretop, E, female right valve (ANU 57062), 5/91 40Pc10A, coretop; F–I, *Krithe prolata* n.sp., F, female right valve (ANU 57022), 67GC03, 7 cm, G, female left valve (ANU 57021), H, male left valve (holotype, ANU 57019), 67GC03, 7 cm, I, male right valve (ANU 57020), 67GC03, 56 cm; J–M, *Krithe comma* n.sp., J, male right valve (holotype, ANU 57023), SO-36-61, 12 cm, K, female left valve (ANU 57025), GR5/4, 6 cm, Holocene, L, male left valve (ANU 57024), SO-36-61, 12 cm, M, female right valve (ANU 57026), GR5/4, 6 cm, Holocene.

**Diagnosis.** A very large species of *Krithe* with pronounced sexual dimorphism. Males elongate subrectangular in lateral view, females much shorter. In both sexes dorsal margin is weakly convex, almost straight in LV. Posterior margin steeply inclined with shallow indentation. Inner lamella narrow posterodorsally. Anterior vestibulum moderately large and subtriangular. ADRPC of type 2B. Dorsal adductor scar is narrow with an anterior and a medial dorsally directed lobes.

**Description.** Carapace large, strongly sexually dimorphic: in lateral outline males elongate subrectangular, females subrectangular and considerably shorter. Dorsal margin in both sexes gently convex throughout, except in RV which has a very slight concavity at anterior quarter of length. Anterior margin strongly convex; posterior margin truncate and steeply inclined. Ventral margin straight or weakly concave. Normal valve overlap. Inner lamella narrow dorsally and mid ventrally, moderately wide elsewhere. Anterior vestibulum subtriangular in lateral aspect and weakly upturned distally. ARPC's short to moderately long. ADRPC of type 2B. AD 1 often a short false RPC or a normal pore. AD 2 and 4 are normal pores. Posterior vestibulum moderately deep with wide neck. Muscle scars large, outline of the upper adductor is a reclined "F" shape.

**Remarks.** The species can be confused with *K. antisawanensis* which differs mainly in its ADRPC type. The shape of the adductor muscle scars also serves to readily distinguish the species. A similarly elongate species from the Miocene of the Exmouth Plateau, Indian Ocean, is illustrated by Guernet (1993, pl. 1, fig. 10) and may be conspecific; internal features were not given.

**Distribution.** *Krithe prolata* occurs rarely on the eastern Australian continental slope from 1270 to 1989 m.

**Stratigraphical range.** Late Pleistocene (NN 21) to Recent, based on piston core records from the Australian Continental Slope.

***Krithe comma* n.sp.**

Figs. 2G,H, 5J–M, 8U,V

**Etymology.** Latin, mark of punctuation. Referring to the lateral outline of this species resembling a comma.

**Type material and dimensions.** HOLOTYPE, ANU 57023, male RV, length 1.12 mm, height 0.48 mm. PARATYPES: ANU 57024, male LV, length 1.13 mm, height 0.52 mm, core SO-36-61, interval 12 cm; ANU 57025, female LV, length 1.03 mm, height 0.53 mm, core GR 5/4, interval 6–8 cm; ANU 57026, male RV, length 1.05 mm, height 0.45 mm, core GR 5/4, interval 6–8 cm. In age specimens from SO-36-61 are latest Pleistocene; those from GR 5/4 are Holocene.

**Type locality and horizon.** Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne core 36-61, interval 12–13 cm, latest Pleistocene.

**Diagnosis.** A very large, compressed species of *Krithe* with strong sexual dimorphism. Males elongate with long posterodorsal slope and deep posterior indentation. Inner lamella wide posterodorsally. Anterior vestibulum rhomboidal and only weakly distally expanded, particularly dorsally. ADRPC of type 2A; AD 3 is a short RPC, AD 4 is a normal pore. Upper two adductor scars are frequently subdivided.

**Description.** Carapace very large, very weakly inflated, strongly sexually dimorphic. In lateral outline males are subrectangular, females considerably shorter, and more truncate posteriorly. Dorsal margin in both sexes straight and parallel with ventral margin through anterior two thirds of valve length, convex posteriorly tapering to a distinct mid-posterior shoulder. Posteroventral margin truncate with deep indentation. Ventral margin variably straight to gently concave. Normal valve overlap. Inner lamella moderately wide dorsally and ventrally, very wide anteriorly. Anterior vestibulum moderately large, rhomboidal with variable neck width, and only weakly distally expanded particularly dorsally. ARPC's are long. ADRPC of type 2A. AD 1 a short RPC or normal pore, AD 3 a short RPC rarely a normal pore, and AD 4 a normal pore emergent just behind the line of concrescence. Posterior vestibulum moderately narrow. Muscle scars large, the upper two adductors usually subdivided.

**Remarks.** The species has the unusual ADRPC pattern of type 2A, a pattern unrepresented in Atlantic species. It shares this pattern, and many other internal features, with *K. pseudocomma*. However, *K. comma* is easily distinguished from that species by its much weaker inflation, more produced posterior, and less ventrally expanded vestibulum.

**Distribution.** A species occurring at relatively shallow depths (702 to 1340 m) only on the Lord Howe Rise.

**Stratigraphical range.** Middle Miocene (NN 6) to Recent, based on core records of DSDP sites 207, 284, 592 and 593. This species occurs commonly throughout its range, and probably evolved from *K. pseudocomma*.

***Krithe dilata* n.sp.**

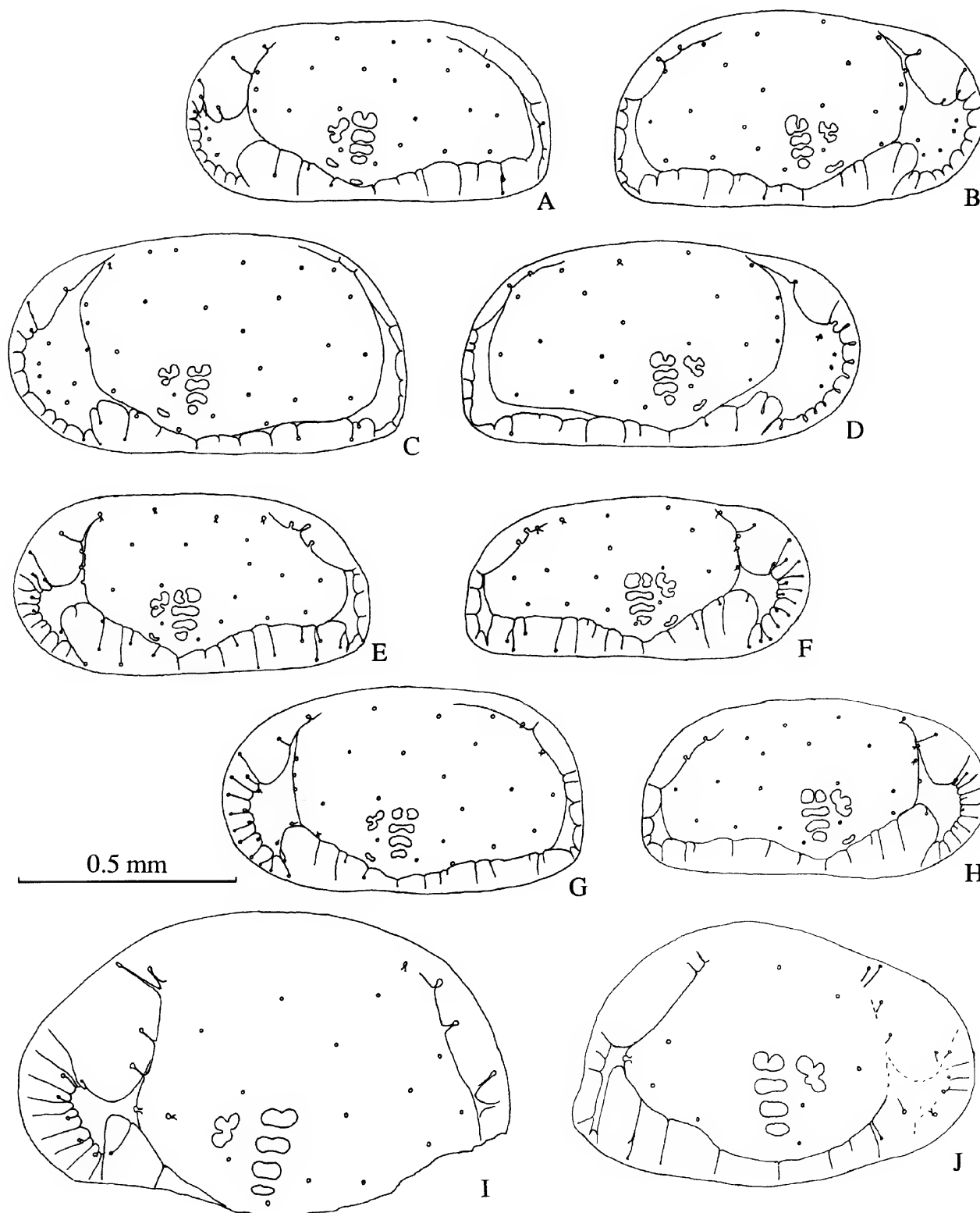
Figs. 6A–D, 8W,X

*Krithe* sp.—Swanson, 1979: 33; fig. 43.

*Krithe* sp. 1.—Ruan & Hao, 1988: 271; pl. 44, figs. 23–25; pl. 45, figs. 1, 2.

**Etymology.** Latin, dilate. Referring to the considerable expansion of the anterior vestibulum often displayed in this species.

**Type material and dimensions.** HOLOTYPE, ANU 57031, female RV, length 1.00 mm, height 0.51 mm. PARATYPES: ANU 57032, female LV, length 0.99 mm, height 0.56 mm, core 71GC044, interval 1.00–1.01 m; ANU 57033, female RV, length 0.92 mm, height 0.49 mm, core 71GC044,



**Figure 6.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A–D, *Krithe dilata* n.sp., A, male left valve (ANU 57016), 105GC20, coretop, B, female right valve (ANU 57033), 71GC44, 100 cm, C, female left valve (ANU 57032), 71GC44, 100 cm, D, female right valve (holotype, ANU 57031), 71GC44, 100 cm; E–H, *Krithe pseudocomma* n.sp., E, male left valve (holotype, ANU 57027), GR5/4, 6 cm, Holocene, F, male right valve (ANU 57028), GR5/4, 2 cm, Holocene, G, female left valve (ANU 57029), GR5/4, 2 cm, Holocene, H, female right valve (ANU 57030), GR5/4, 4 cm, Holocene; I, J, *Krithe* sp. 2, I, female left valve (ANU 57064), TL8758, coretop, J, female right valve (ANU 57065), 12/87 12GC9, 65 cm.

interval 1.00–1.01 m; ANU 57016, length 0.91 mm, height 0.45 mm, coretop 105GC20. Specimens from 71GC044 are late Pleistocene in age.

**Type locality and horizon.** Tasman Sea, off eastern Australia present day water depth 1321 m, AGSO core 71GC044, interval 1.00–1.01 m, latest Pleistocene.

**Diagnosis.** A large, subrectangular species of *Krithe* with weak sexual dimorphism. Males lower than females. Posterior margin very truncate with a very shallow posterior indentation. Inner lamella narrow posterodorsally. Anterior vestibulum mushroom-shaped, often with extremely wide proximal expansion. ADRPC of type 2B; AD 1 is usually a normal pore sometimes a short RPC, AD 3 and 4 are normal pores.

**Description.** Carapace moderately large and rectangular. Dorsal and ventral margins are straight and subparallel. Anterior margin regularly convex; posterior margin rounded dorsally, truncate ventrally with no median shoulder and only weakly indented. Normal valve overlap. Inner lamella narrow posterodorsally and mid ventrally, moderately wide elsewhere. Anterior vestibulum large and mushroom-shaped with variable neck width, usually wide. ARPC's are short. ADRPC of type 2B. AD 1 is usually a normal pore sometimes a short RPC. AD 3 and 4 are normal pores. Posterior vestibulum is very narrow but often expanded proximally. Muscle scars large, undivided.

**Remarks.** The species is most similar to *K. comma* n.sp. and *K. pseudocomma* n.sp. It differs from those species, however, in its more symmetrical and greatly expanded anterior vestibulum, and its undivided adductor scars. The Atlantic Palaeogene species *Krithe regulare* Coles *et al.*, 1994, is also very similar, despite the considerable difference in geographical locality and stratigraphical range. Morphologically, *K. dilata* differs in size, having a more rounded posterior and much less marked sexual dimorphism.

**Distribution.** A relatively shallow occurring species recorded in this study between 355 to 1321 m on the eastern Australian continental slope.

**Stratigraphical range.** Early Pliocene (NN 14) to Recent, based on core records of DSDP site 593.

### *Krithe pseudocomma* n.sp.

Figs. 6E–H, 8Y,Z

**Etymology.** Latin, referring to the close resemblance of this species to *Krithe comma* n.sp.

**Type material and dimensions.** HOLOTYPE, ANU 57027, male LV, length 0.88 mm, height 0.44 mm. PARATYPES: ANU 57028, male RV, length 0.86 mm, height 0.40 mm, core GR 5/4, interval 2–4 cm; ANU 57029, female LV, length 0.90 mm, height 0.52 mm, core GR 5/4, interval 2–4 cm; ANU 57030, female RV, length 0.86 mm, height 0.45

mm, core GR 5/4, interval 4–6 cm; All specimens are Holocene in age.

**Type locality and horizon.** Challenger Plateau, present day water depth 686 m, GRAINZ core 5/4, interval 2–4 cm, Holocene.

**Diagnosis.** A large, subrectangular species of *Krithe* with weak sexual dimorphism. Males lower than females. Posterior margin very truncate with a very shallow posterior indentation. Inner lamella wide posterodorsally. Anterior vestibulum crescentic, with distinct ventral distal expansion. ADRPC of type 2B; AD 3 and 4 are normal pores. The uppermost adductor scar is subdivided.

**Description.** Carapace large, strongly inflated, weakly sexually dimorphic, males lower than females. Dorsal margin straight to slightly convex and parallel with ventral margin, which is very slightly concave. Posterior margin truncate with shallow indentation. Normal overlap. Inner lamella moderately wide. Anterior vestibulum hook-shaped with variable neck width, strongly distally expanded ventrally. ARPC's are moderately long. ADRPC of type 2B. AD 1 is a short RPC or normal pore, AD 3 and AD 4 are normal pores. Posterior vestibulum is narrow. Muscle scars large, the upper adductor is subdivided.

**Remarks.** Internal carapace features of this species are similar to those of *K. comma* n.sp. as are certain aspects of its external morphology. However, there is a slight difference in ADRPC pattern: *K. pseudocomma* has an ADRPC of type 2B since AD 3 and AD 4 are always normal pores, whereas in *K. comma* AD 3 is usually a short RPC and, therefore, has an ADRPC of type 2A. Moreover, *K. pseudocomma* differs significantly from *K. comma* in its more cylindrical shape and its ventral distally expanded anterior vestibulum.

**Distribution.** Occurs only on the Lord Howe Rise and Challenger Plateau, ranging in depth from 686 to 1389 m.

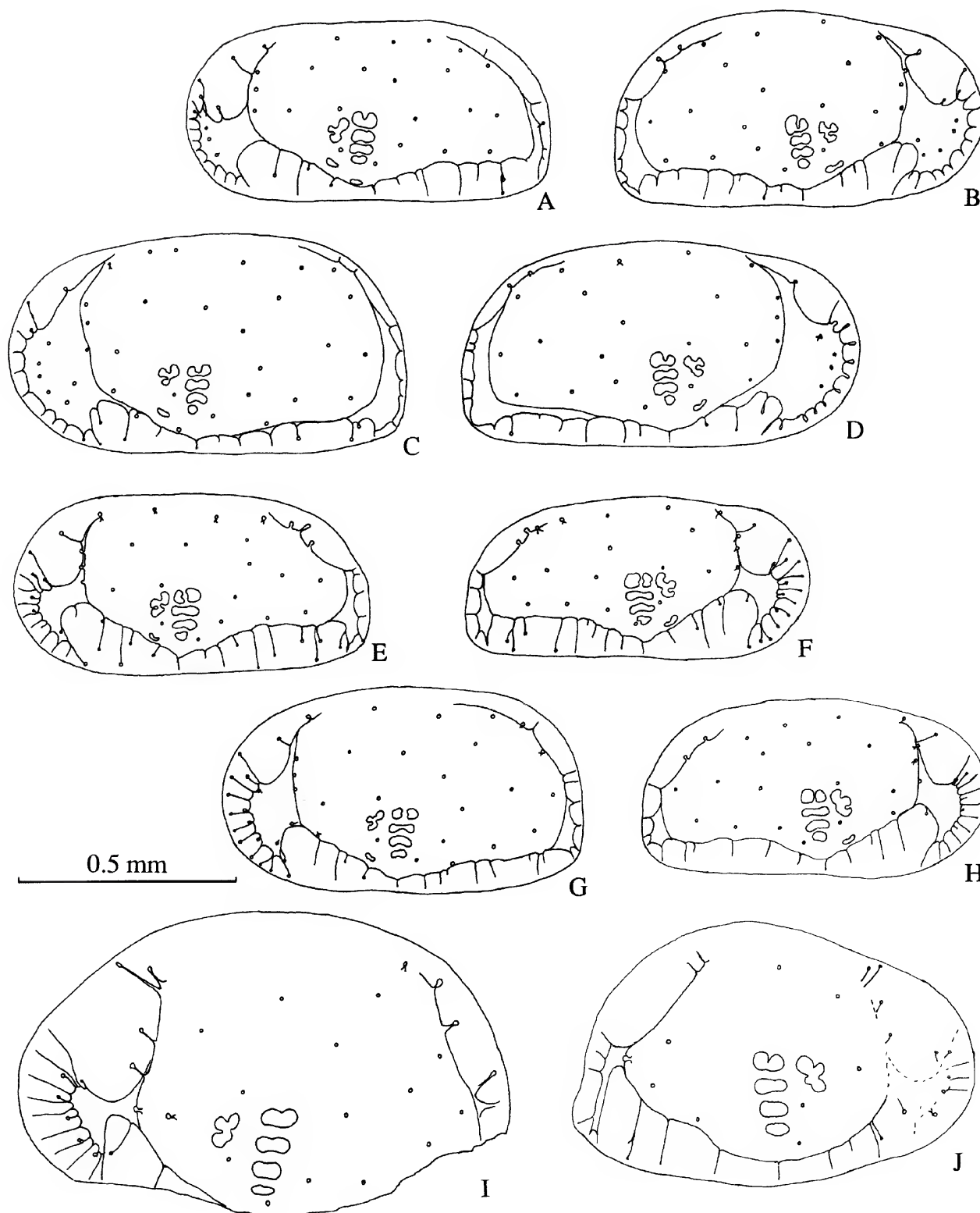
**Stratigraphical range.** Early Miocene (NN 1) to Recent, based on core records of DSDP sites 207, 284, 592 and 593.

### *Krithe* sp. 2

Figs. 6I,J, 8AA

**Description.** Female carapace extremely large, well inflated and heavily calcified. Dorsal margin is strongly convex; ventral margin less so. Anterior margin strongly convex, weakly concave dorsally. Posterior margin very truncate with weak posterior indentation. Normal valve overlap. Inner lamella is wide anteriorly and posteriorly, moderately wide ventrally. Anterior vestibulum narrow and mushroom shaped. ARPC's are moderately long. ADRPC of type 2B. AD 2 is very long and very close to the dorsal margin. Posterior vestibulum very narrow. Muscle scars large and not subdivided.





**Figure 6.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A–D, *Krithe dilatata* n.sp., A, male left valve (ANU 57016), 105GC20, coretop, B, female right valve (ANU 57033), 71GC44, 100 cm, C, female left valve (ANU 57032), 71GC44, 100 cm, D, female right valve (holotype, ANU 57031), 71GC44, 100 cm; E–H, *Krithe pseudocomma* n.sp., E, male left valve (holotype, ANU 57027), GR5/4, 6 cm, Holocene, F, male right valve (ANU 57028), GR5/4, 2 cm, Holocene, G, female left valve (ANU 57029), GR5/4, 2 cm, Holocene, H, female right valve (ANU 57030), GR5/4, 4 cm, Holocene; I, J, *Krithe* sp. 2, I, female left valve (ANU 57064), TL8758, coretop, J, female right valve (ANU 57065), 12/87 12GC9, 65 cm.

**Remarks.** Only a few poorly preserved, probably female, specimens were found. In overall morphology they resemble *K. trinidadensis* but the ADRPC pattern is very different.

**Distribution.** Found at 1545 to 3281 m on the flanks and plateau of the Lord Howe Rise.

**Stratigraphical range.** Early Miocene (NN 1) to Recent, based on core records of DSDP sites 208.

### ADRPC TYPE 3

*Krithe morkhoveni morkhoveni* Bold, 1960

Figs. 7A–C, 8DD,EE

For comprehensive pre-1988 synonymy see Coles *et al.* (1994).

*Krithe morkhoveni* Bold, 1960: 160; pl. 3, fig. 6.

*Krithe* sp. 11 Whatley & Zhao, 1993: fig. 3.11.

*Krithe undecimradiata* Ruggieri; Abate, Barra, Aiello & Bonaduce, 1993: 364; pl. 5, figs. 1–3.

*Krithe morkhoveni morkhoveni* Bold; Coles, Whatley & Moguilevsky, 1994: 94; pl. 3, figs. 11–18, text-fig. 4D–H.

**Remarks.** This species is significantly smaller (see Fig. 9) than the very similar species *K. trinidadensis*.

**Distribution.** A species common on the Continental Slope of Australia, recorded from 804 to 3552 m, but almost absent elsewhere in the Tasman Sea being found only at one site at 1125 m on the Challenger Plateau.

**Stratigraphical range.** Early Pliocene (NN 15) to Recent, based on core records of DSDP site 208 and GR5/4. It is known elsewhere from the Late Palaeocene onwards (Coles *et al.*, 1994), but in our Neogene cores from the Lord Howe Rise it is only very poorly represented.

*Krithe pernoides sinuosa* Ciampo, 1986

Figs. 7D–G, 8BB,CC

For comprehensive pre-1988 synonymy see Coles *et al.* (1994).

*Krithe sinuosa* Ciampo, 1986: 87; pl. 17, figs. 3, 5.

*Krithe introcurva* Hao in Ruan & Hao, 1988: 267; pl. 40, figs. 26–28.

*Krithe pernoides* (Bornemann); Abate, Barra, Aiello & Bonaduce, 1993: 362; pl. 2, figs. 8–11, pl. 3, fig. 13, pl. 6, fig. 10 (small form).

*Krithe* sp. 7 Whatley & Zhao, 1993: fig. 3.10.

*Krithe pernoides sinuosa* Ciampo; Coles, Whatley & Moguilevsky, 1994: 106; pl. 5, figs. 13–17, text-fig. 5R–V.

**Distribution.** Found only off eastern Australia restricted to a narrow depth range of 1274 to 1467 m.

**Stratigraphical range.** Early Pliocene (NN 14) to Recent, based on core records of DSDP sites 206 and piston cores on the Australian Continental Slope. The subspecies is known from the Early Miocene elsewhere (Coles *et al.*, 1994).

*Krithe trinidadensis* Bold, 1958

Figs. 2I,J, 7H–L, 8FF,GG

For comprehensive synonymy see Coles *et al.* (1994).

*Krithe trinidadensis* Bold, 1958: 398; pl. 1, figs. 3a, 3c,d, 3f, 6e.–

Coles, Whatley & Moguilevsky, 1994: 99; pl. 4, figs. 7–12; text-fig. 4P–T, text-fig. 5A,B.

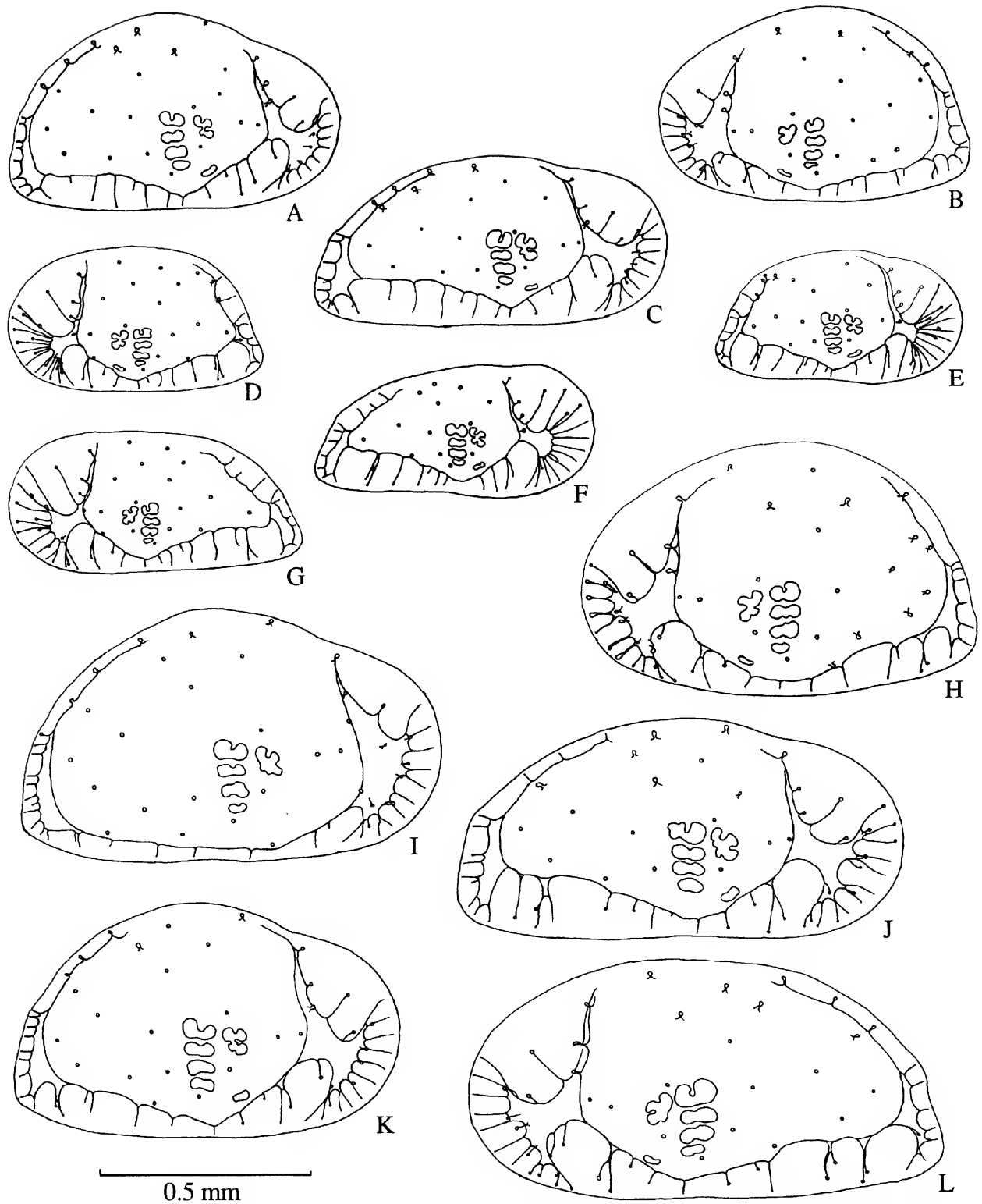
**Remarks.** The large size of this species (see Fig. 9) readily serves to distinguish it from the smaller, but otherwise very similar species, *K. morkhoveni morkhoveni* Bold.

**Distribution.** In coretop material we found this species only on the Continental Slope off Tasmania at a depth range of 1476 to 2346 m. Elsewhere in our study region it has been recorded rarely only as fossil in DSDP site 206, 3196 m in the New Caledonian Basin.

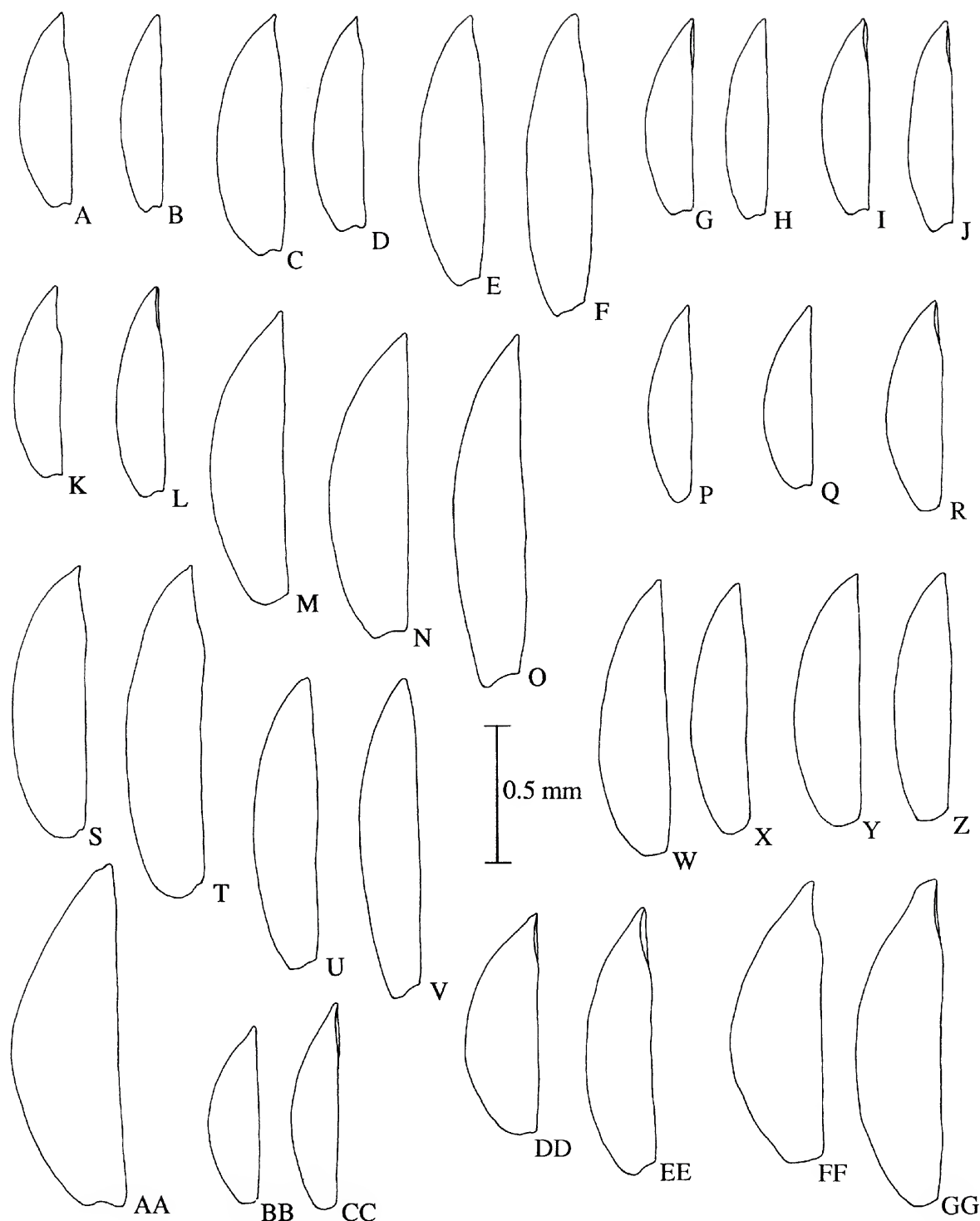
**Stratigraphical range.** Late Pliocene (NN 16) to Recent, based on core records of DSDP site 206. *Krithe trinidadensis* is known to occur from the Middle Eocene zone NP 16 (Coles *et al.*, 1994).

### Discussion

Table 1 shows the depth distribution of all the species found in the two study regions, the East Tasman Sea (including the New Caledonia Basin, Lord Howe Rise and Challenger Plateau) and the Continental Slope off southern and eastern Australia. As in other parts of the world oceans greatest diversity occurs beyond 1,000 m in the bathyal and abyssal environment. In both our study areas some 15 species occur, or have occurred in the past. Not all of them, however, are common to both regions. Five species are absent from the Australian Continental Slope. They include *K. comma*, *K. pseudocomma*, *Krithe* sp. 2, these being confined to the plateau or flanks of the Lord Howe Rise; and *K. dolichodeira* and *K. minima*, which are geographically and bathymetrically widespread species, common, for example in the North Atlantic (Coles *et al.*, 1994). The absence from the slope regions of Australia of these two, otherwise cosmopolitan species, is perplexing. Three species, *K. posticliva*, *K. pernoides sinuosa*, and *K. trinidadensis* appear to have diminished their range, since they are recorded in modern sediments off Australia, but only in ancient sediments in the East Tasman Sea. Four other species, *K. dilata*, *K. perpulchra*, *K. prolata* and *Krithe* sp. 1, are restricted entirely to the Australian Continental Slope. Vertical range distribution of ubiquitous species likely relates to variations of vertical watermass structure and substrate type. The relatively steep-sided Australian Continental Slope offers only narrow areas of uniform watermass, and generally unstable, terrigenous rich

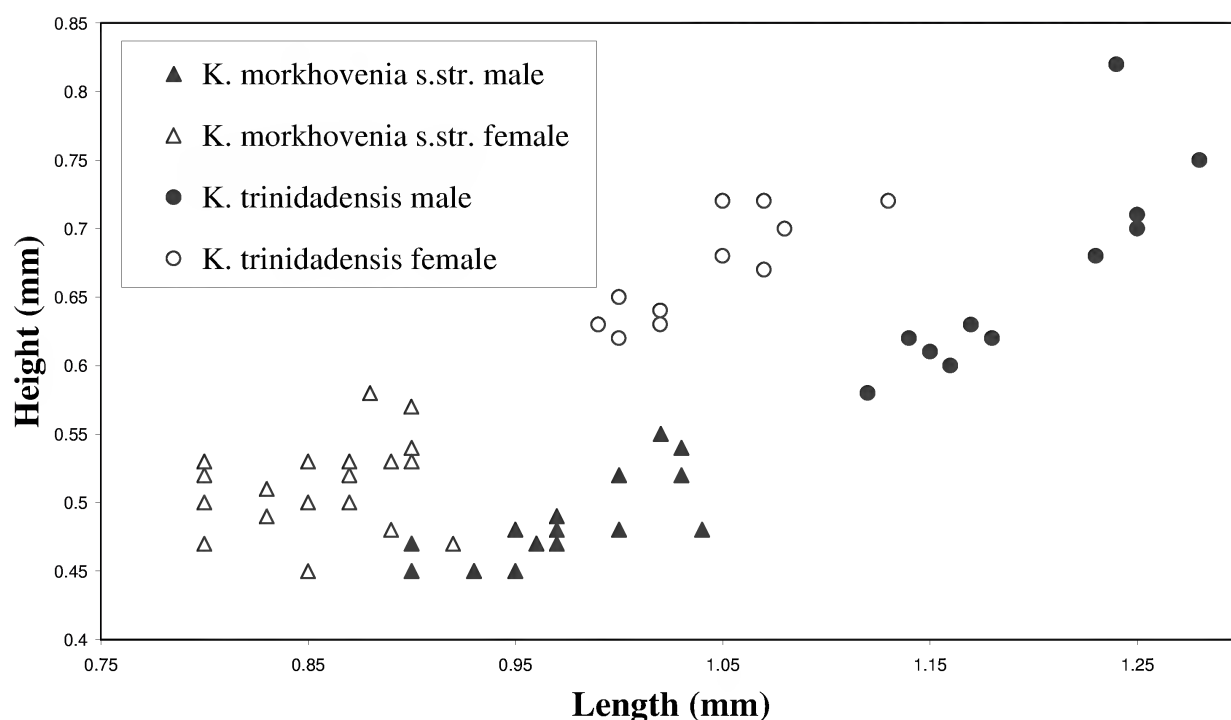


**Figure 7.** Camera lucida drawings of internal valve features. All figures are external views. All specimens are of late Pleistocene age unless otherwise indicated. A–C, *Krithe morkhoveni morkhoveni* Bold, A, female right valve (ANU 57067), 9/86 Pc7, 84 cm, B, female left valve (ANU 57066), 67GC03, 25 cm, C, male right valve (ANU 57069), 67GC03, 107 cm; D–G, *Krithe pernoides sinuosa* Ciampo, D, female left valve (ANU 57070), 71GC44, 45 cm, E, female right valve (ANU 57071), 71GC44, 45 cm, F, male right valve (ANU 57073), 71GC44, 45 cm, G, male left valve (ANU 57072), 112GC9, coretop; H–L, *Krithe trinidadensis* Bold, H, female left valve (ANU 57074), 67GC03, 25 cm, I, female right valve, form with large anterior vestibulum (ANU 57075), 67GC03, 280 cm, J, male right valve (ANU 57078), 67GC03, 25 cm, K, female right valve (ANU 57076), 67GC03, 177 cm, L, male left valve (ANU 57077), 67GC03, 137 cm.



**Figure 8.** Camera lucida drawings of left valve profile in dorsal view. A, B, *Krithe compressa*, A, female, ANU 57035, B, male, ANU 57037; C, D, *Krithe antisawanensis*, C, female, ANU 57039, D, male, ANU 57044; E, F, *Krithe dolichodeira*, E, female, ANU 57043, F, male, ANU 57045, G, H, *Krithe marialuisae*, G, female, ANU 57047, H, male, ANU 57049; I, J, *Krithe minima*, I, female, ANU 57051, J, male, ANU 57053; K, L, *Krithe posticliva*, K, female, ANU 57055, L, male, ANU 57057; M, *Krithe reversa*, female, ANU 57034; N, O, *Krithe triangularis*, N, female, ANU 57013, O, male, ANU 57011; P, *Krithe* sp. 1, female?, ANU 57017; Q, *Krithe droogeri*, female, ANU 57059; R, *Krithe perpulchra*, female, ANU 57061; S, T, *Krithe prolata*, S, female, ANU 57021, T, male, ANU 57019; U, V, *Krithe comma*, U, female, ANU 57029, V, male, ANU 57024; W, X, *Krithe dilata*, W, female, ANU 57032, X, male, ANU 57016; Y, Z, *Krithe pseudocomma*, Y, female, ANU 57029, Z, male, ANU 57027; AA, *Krithe* sp. 2, female, ANU 57064; BB, CC, *Krithe pernoides sinuosa*, BB, female, ANU 57070, CC, male, ANU 57072; DD, EE, *Krithe morkhoveni morkhoveni*, DD, female, ANU 57066, EE, male, ANU 57068; FF, GG, *Krithe trinidadensis*, FF, female, ANU 57074, GG, male, ANU 57077.





**Figure 9.** Size variation in adult *Krithe morkhoveni morkhoveni* and *Krithe trinidadensis*.

sediment regimes. Whereas the plateau regions of the eastern Tasman Sea are relatively stable, carbonate rich areas. These factors must have a profound influence upon the distribution of any benthonic living community.

Table 2 shows the stratigraphic ranges of all the species documented here. The success of the genus is striking, with a radiation throughout the Neogene from three species in the Early Miocene, to 19 by the Late Pleistocene. By comparison with the North Atlantic (Coles *et al.*, 1994), this diversity trend appears to be a global one. Of the seven species shared with the North Atlantic none appear at the same time in each ocean. Only two species, *K. minima* and *K. triangularis*, have earlier occurrences in the Southwest Pacific and, therefore, have probably evolved there. The Late Miocene to Late Pliocene saw the invasion of the Pacific of most of the Atlantic shared species. Further work is needed on Palaeogene occurrences in the Pacific to make further definite comparisons here concerning migration patterns and inter-oceanic correlation. It is clear, however, that the Pacific fauna consists of a mix of immigrant and endemic species. There exist species, characterised by ADRPC Type 2A (*K. comma*, and *K. pseudocomma*), that have remained in the Southwest Pacific region throughout their long, at least Miocene to Recent, range.

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**Table 1.** Bathymetric distribution of *Krithe* species and location details of sites considered in this report. ● = present; ○ = Lazarus occurrences; + = fossil occurrence only.

site	latitude S	longitude E	depth (m)	map code	<i>conna</i>	<i>pseudocomma</i>	<i>dolichodeira</i>	<i>antisawanensis</i>	<i>reversa</i>	<i>triangularis</i>	<i>minima</i>	<i>marialuisae</i>	<i>compressa</i>	<i>posticliva</i>	<i>droogeri</i>	<i>mor-khovei</i> s.str.	<i>Krithe</i> sp. 2	<i>pernoides sinuosa</i>	<i>trinidadensis</i>	<i>Krithe</i> sp. 1	<i>dilatata</i>	<i>perpulchra</i>	<i>prolata</i>
Australian Continental Slope																							
AGSO 105GC20	26.502°	153.825°	355	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	-	-
Fr5-91 41PC11	34.173°	151.603°	759	34	-	-	-	-	-	-	-	-	●	-	-	-	-	-	-	-	○	●	-
Fr5-91 40PC10A	34.352°	151.470°	773	28	-	-	-	-	-	-	-	-	○	-	-	-	-	-	-	-	●	●	-
Fr5-91 35PC9	35.538°	150.803°	804	27	-	-	-	-	-	-	-	-	●	-	-	●	-	-	-	-	●	-	-
Fr2/91 106C	36.993°	137.557°	835	1	-	-	-	-	-	-	-	-	○	-	-	●	-	-	-	-	○	-	-
AGSO 112/GC08	33.925°	151.858°	977	37	-	-	-	●	-	-	-	-	○	-	-	●	-	-	-	-	○	-	-
AGSO 71GC7	29.353°	153.875°	989	44	-	-	-	○	-	-	-	-	○	●	-	●	-	-	-	-	●	-	-
AGSO 105GC25	26.585°	153.852°	1022	42	-	-	-	○	●	-	-	-	○	○	-	○	-	-	-	-	○	-	-
Fr5-91 9GC9	34.150°	151.600°	1040	35	-	-	-	○	○	-	-	-	○	○	-	●	-	-	-	-	○	-	-
Fr1-91 24PC5	34.385°	151.515°	1048	30	-	-	-	●	○	-	-	-	○	○	-	●	-	-	-	-	○	-	-
AGSO 67/GC50	41.508°	144.290°	1081	21	-	-	-	●	○	-	-	-	○	○	-	○	-	-	-	-	○	-	-
AGSO 67/GC52	41.182°	143.958°	1145	19	-	-	-	●	○	-	-	-	○	○	-	○	-	-	-	-	○	-	-
AGSO 67/GC23	38.053°	139.932°	1146	5	-	-	-	●	○	-	-	-	○	○	-	○	-	-	-	-	○	-	-
AGSO 105GC13	25.255°	153.875°	1200	43	-	-	-	○	○	-	-	-	○	○	●	●	-	-	-	-	○	-	-
AGSO 67/GC32	39.668°	142.912°	1244	18	-	-	-	●	○	-	-	-	○	○	○	○	-	-	-	-	○	-	-
AGSO 67/GC02	37.398°	138.578°	1270	2	-	-	-	○	○	-	-	-	○	○	○	○	-	-	-	-	○	-	●
Fr9-86 PC7	34.325°	151.570°	1274	33	-	-	-	●	●	-	-	-	○	●	○	●	-	●	-	-	○	-	○
AGSO 71GC044	29.524°	153.900°	1321	45	-	-	-	○	○	-	-	-	●	●	○	●	-	●	-	-	●	-	○
Fr5-91 26PC7	34.505°	151.480°	1405	29	-	-	-	○	●	-	-	-	○	○	○	●	-	○	-	-	-	-	○
AGSO 67/GC33	39.758°	142.867°	1433	17	-	-	-	●	○	-	-	-	○	○	○	●	-	○	-	-	-	-	○
Fr5-91 19PC3	34.395°	151.532°	1458	31	-	-	-	○	○	-	-	-	○	○	○	●	-	○	-	-	-	-	○
AGSO 112GC9	33.950°	151.923°	1467	39	-	-	-	○	○	-	-	-	●	○	○	●	-	●	-	-	-	-	○
AGSO 67/GC03	37.550°	138.583°	1476	3	-	-	-	●	●	-	-	-	○	○	○	○	-	-	●	-	-	-	●
AGSO 67/GC17	38.287°	140.185°	1490	10	-	-	-	●	○	-	-	-	○	○	○	○	-	-	○	-	-	-	-
Fr2-91 163G	38.520°	140.544°	1523	13	-	-	-	●	●	-	-	-	○	○	○	●	-	-	○	-	-	-	○
AGSO 67/GC04	37.583°	138.583°	1526	4	-	-	-	○	○	-	-	-	○	○	○	○	-	-	●	-	-	-	●
E53-20	41.433°	144.102°	1533	20	-	-	-	●	●	-	-	-	○	○	○	●	-	-	○	-	-	-	-
AGSO 67/GC34	39.795°	142.813°	1630	16	-	-	-	●	●	-	-	●	○	○	○	○	-	-	○	-	-	-	-
AGSO 67/GC16	38.333°	140.182°	1650	9	-	-	-	○	○	-	-	●	○	○	○	●	-	-	○	-	-	-	-
Fr5-91 43GC11	34.102°	151.842°	1818	36	-	-	-	○	○	●	-	○	○	○	○	○	-	-	○	-	-	-	-
Fr2/91 162G	38.518°	140.411°	1880	12	-	-	-	●	●	○	-	●	○	○	○	●	-	-	○	-	-	-	-
Fr1-94 GR 1	46.251°	146.541°	1900	23	-	-	-	●	●	●	-	○	○	○	○	○	-	-	○	-	-	-	-
AGSO 67/GC15	38.382°	140.177°	1964	8	-	-	-	○	●	○	-	○	○	○	○	●	-	-	○	-	-	-	-
AGSO 71GC026	29.310°	154.067°	1989	46	-	-	-	●	●	●	-	○	○	●	●	-	-	-	○	-	-	-	-
Fr5-91 25PC6	34.425°	151.567°	1996	32	-	-	-	○	○	○	-	○	○	-	-	●	-	-	○	-	-	-	-
AGSO 112GC10	33.983°	152.000°	2007	40	-	-	-	○	○	○	-	○	○	-	-	●	-	-	○	-	-	-	-
AGSO 67/GC14	38.423°	140.165°	2250	6	-	-	-	○	●	○	-	●	○	-	-	●	-	-	○	-	-	-	-
E55-6	38.853°	141.063°	2346	14	-	-	-	●	●	●	-	●	○	-	-	●	-	-	●	-	-	-	-
AGSO 67/GC46	42.202°	144.413°	2360	22	-	-	-	○	○	○	-	○	●	-	-	●	-	-	-	-	-	-	-
Fr5/91 14PC1	34.125°	151.868°	2373	38	-	-	-	○	○	●	-	○	-	-	-	●	-	-	-	-	-	-	-
Fr2-91 161G	38.527°	140.210°	2450	11	-	-	-	●	●	○	-	-	-	-	-	●	-	-	-	-	-	-	-
E36-23	43.883°	150.050°	2521	26	-	-	-	●	●	●	-	-	-	-	-	●	-	-	-	-	-	-	-
AGSO 67GC/13	38.465°	140.167°	2525	7	-	-	-	○	●	○	-	-	-	-	-	●	-	-	-	-	-	-	-
Fr1/94 GC3	44.256°	149.991°	2667	25	-	-	-	●	●	●	-	-	-	-	-	●	-	-	-	-	-	-	-
AGSO 67/GC37	40.235°	142.425°	3090	15	-	-	-	●	○	○	-	-	-	-	-	○	-	-	-	-	-	-	-
TS 8925	28.240°	159.150°	3403	52	-	-	-	●	○	○	-	-	-	-	-	○	-	-	-	-	-	-	-
E27-30	45.067°	147.228°	3552	24	-	-	-	-	●	○	-	-	-	-	-	●	-	-	-	-	-	-	-
Fr1/86 24GC15	30.860°	156.790°	4470	48	-	-	-	-	-	●	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. Continued.

site	latitude S	longitude E	depth (m)	map code	<i>comma</i>	<i>pseudocomma</i>	<i>dolichodeira</i>	<i>antisawanensis</i>	<i>reversa</i>	<i>triangularis</i>	<i>minima</i>	<i>marialuisae</i>	<i>compressa</i>	<i>posticlivia</i>	<i>droogeri</i>	<i>morkhoveni</i> s.str.	<i>Krithe</i> sp. 2	<i>permoides sinuosa</i>	<i>trinidadensis</i>	<i>Krithe</i> sp. 1	<i>dilatata</i>	<i>perpulchra</i>	<i>prolata</i>
<b>East Tasman Sea</b>																							
GR 5/4	41.152°	170.342°	686	72	●	●	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WB 95-3	40.218°	169.645°	850	71	●	○	●	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DSDP 284	40.508°	167.680°	1066	68	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
DSDP 593	40.508°	167.675°	1068	67	+	+	+	+	○	+	+	+	+	+	-	-	-	-	-	-	-	-	-
DSDP 592	36.473°	165.442°	1088	62	+	+	+	+	○	+	+	+	+	-	+	-	-	-	-	-	-	-	-
Q698	42.473°	169.133°	1100	69	●	○	○	○	●	○	○	○	○	-	○	-	-	-	-	-	-	-	-
WB 95-1	42.247°	169.508°	1125	70	●	●	●	●	●	●	●	●	○	-	○	●	-	-	-	-	-	-	-
RC9-128 TL 8731	36.130°	166.070°	1234	64	○	○	○	○	○	○	○	○	○	-	○	○	-	-	-	-	-	-	-
SO 36-61	30.550°	161.438°	1340	58	●	○	●	○	○	○	●	●	●	-	○	○	-	-	-	-	-	-	-
DSDP 207	36.963°	165.434°	1389	61	+	+	+	+	+	+	+	+	○	-	○	○	-	-	-	-	-	-	-
OSI 12-87 13GC10	29.258°	161.255°	1416	56	-	-	○	●	●	○	○	○	○	-	○	○	-	-	-	-	-	-	-
Z2108	33.376°	161.612°	1448	59	-	-	●	●	●	●	●	●	●	-	○	○	-	-	-	-	-	-	-
TL 8730	34.010°	167.540°	1533	66	-	-	○	●	○	○	○	○	○	-	○	○	-	-	-	-	-	-	-
OSI 1-86 6GC3	32.980°	159.998°	1540	54	-	-	●	●	○	○	○	○	○	-	○	○	-	-	-	-	-	-	-
DSDP 208	26.110°	161.221°	1545	55	-	-	+	+	+	+	+	+	+	-	○	+	-	-	-	-	-	-	-
TS 8648	28.080°	161.310°	1607	57	-	-	○	●	○	●	●	●	○	-	○	-	○	-	-	-	-	-	-
TL 8759	26.000°	154.540°	1942	47	-	-	●	○	○	○	○	○	○	-	○	-	○	-	-	-	-	-	-
Fr 1-86 19GC11	29.960°	159.841°	2067	53	-	-	●	●	●	○	○	○	○	-	○	-	○	-	-	-	-	-	-
TL 8646	28.120°	158.130°	2220	50	-	-	○	●	○	○	○	○	○	-	○	-	○	-	-	-	-	-	-
TS 8647	28.080°	158.190°	2253	51	-	-	○	○	○	○	○	○	○	-	○	-	●	-	-	-	-	-	-
TS 8656	33.320°	166.320°	2860	65	-	-	●	○	○	○	○	○	○	-	○	-	○	-	-	-	-	-	-
TL 8758	25.530°	157.520°	2930	49	-	-	○	○	○	○	○	-	●	-	○	-	●	-	-	-	-	-	-
DSDP 206	32.013°	165.453°	3196	63	-	-	+	+	+	○	+	-	○	-	+	-	○	+	+	-	-	-	-
Fr12-87 12GC9	27.387°	165.338°	3281	60	-	-	●	●	-	●	●	-	●	-	-	-	●	-	-	-	-	-	-

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## Two Solenogaster Molluscs, *Ocheyoherpia trachia* n.sp. from Macquarie Island and *Tegulaherpia tasmanica* Salvini-Plawen from Bass Strait (Aplacophora: Neomeniomorpha)

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**ABSTRACT.** *Tegulaherpia tasmanica* Salvini-Plawen is herein redescribed and illustrated from 22 individuals collected in Bass Strait and expands the original text diagnosis to include illustrations. Similarities between *Tegulaherpia*, which belongs to the Lepidomeniidae, and the written description and figures of *Lepidomenia hystrix* Marion & Kowalevsky, the nominate species for which there is no known type, suggests synonymy.

Nineteen individuals of *Ocheyoherpia trachia* n.sp. were collected at diving depths from Macquarie Island. It is the second species to be described in the previously monotypic subantarctic genus *Ocheyoherpia* Salvini-Plawen and differs from *O. lituifera* in its shorter epidermal spicules, dorsal carina, size of radula, number of copulatory spicules and their relationship to the large copulatory spicule glands, a large dorsal sinus, and thin cuticle. Familial status is shown to be uncertain.

In both *T. tasmanica* and *O. trachia* the morphology of hard parts (epidermal spicules, radula, and copulatory spicules) is emphasized. The reproductive system is described for *T. tasmanica* and remarks made on differences in the reproductive systems of the two *Ocheyoherpia* species.

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The continental shelf and offshore benthos of Australia affords numerous species of Aplacophora (Scheltema, 1998). This short contribution to the benthos of Bass Strait and Macquarie Island is part of a continuing series of descriptions of Australian aplacophoran species.

Seldom have neomenioid aplacophorans—those that creep about on a narrow, ventral ridgelike foot—been

described by placing emphasis on hard-part and external morphologies, although these are characters most readily available for identification. They are a focus of this paper in the certitude that the taxonomy of Aplacophora can be made available to more than the specialist.

## Materials and methods

The species described are from collections made during the Macquarie Island Expedition 1977–78 (Australian Museum) and Bass Strait Survey 1979–1984 (National Museum of Victoria). Holotypes, paratypes, and voucher specimens are deposited in or were borrowed from the Australian Museum (AM), Museum of Victoria (MV), Tasmanian Museum (TM), and the National Museum of Natural History, Washington, DC (USNM).

Holotypes were drawn under a dissecting microscope with the aid of an ocular drawing tube and then photographed. The drawings emphasize spicule attitude and details of the anterior and posterior ends. Measurements were made by a map wheel or by dividers on drawings: *length* is the axial midline of a specimen in lateral view, *height* is the dorsoventral diameter, and *width* the lateral diameter. Epidermal spicules and radulae were treated as in Scheltema (1989), with the exception that radulae were mounted in CMCP-10©, a water-miscible mountant. To obtain isolated copulatory spicules, the posterior end of an individual was cut off and the tissue dissolved in hypochlorite solution (household bleach). A permanent slide was prepared by washing spicules with distilled water and transferring them to a slide with the aid of a micropipetter. After air-drying, a mountant and coverslip were added. Measurements of radulae, epidermal spicules, and copulatory spicules were made with an ocular micrometer. Histologic sections were paraffin embedded and cut at 7 µm or epon embedded and cut at 1.5 µm. The former were stained by hematoxylin and Gray's double contrast or by Mallory-Heidenhain trichrome; epon sections were stained with azure II and methylene blue.

The general anatomy of Neomeniomorpha has been described by Salvini-Plawen (1985a), Scheltema *et al.* (1994), and Scheltema (1998). The arrangement of epidermal spicules are: (a) *skeletal*, lying within the cuticle at right angles to each other in one or more layers spiralled from ventroanterior to dorsoposterior and from dorsoanterior to ventroposterior; (b) *upright*, more or less erect in a single layer, or (c) *adpressed*, with a single layer of overlapping spicules flat against the body wall cuticle. Species may have one or more spicule arrangements and one to several spicule morphologies. Spicules are formed of aragonite; they may be hollow or solid throughout. The radula of neomenioids is *distichous* (two teeth per row), *monostichous* (one tooth per row), or *polystichous* (many teeth per row); it is lacking in 20 percent of known species. Neither distichous nor polystichous radulae have a central, median tooth like the rachidians in gastropod radulae. In distichous radulae the denticles may be borne on a bar attached entirely or partially to the radular membrane, or they may be denticulate hooks largely free of the membrane. In distichous bars, the largest denticles are lateral. During growth denticles are added to new teeth either medially or by bifurcation of a pre-existing denticle.

## Species descriptions

### Neomeniomorpha Pelseneer, 1906

Ventroplicida Boettger, 1956; Solenogastres Gegenbaur, 1878 [*partim*], Salvini-Plawen, 1967. *Non* Neomeniomorpha Salvini-Plawen, 1978.

**Diagnosis.** Aplacophoran molluscs with a narrow footfold in a ventral, longitudinal pedal groove and without a cuticular oral shield or mantle cavity ctenidia; midgut as a combined stomach and digestive gland; monoecious.

**Remarks.** A ventral groove in a spicule-covered, vermiform organism identifies it as a neomenioid mollusc.

### Family Lepidomeniidae Pruvot, 1902

**Type genus.** *Lepidomenia* Kowalevsky in Brock, 1883 (1992, *Bull. Zool. Nomen.* 49: 158, Op. 1676).

**Diagnosis.** Epidermal spicules thin, platelike, adpressed; cuticle thin; radula small, with distichous hooks (Fig. 3B); ventral salivary glands paired, tubular, opening through paired ducts.

**Remarks.** With three genera of small neomenioids, *Lepidomenia* Kowalevsky, 1883, *Nierstraszia* Heath, 1918, and *Tegulaherpia* Salvini-Plawen, 1983.

### *Tegulaherpia* Salvini-Plawen, 1983

**Type species.** *Tegulaherpia stimulosus* Salvini-Plawen, 1983, by monotypy [corrected to *T. stimulosa* (Salvini-Plawen, 1988)].

***Tegulaherpia* distribution.** Bass Strait (Australia), Mediterranean Sea, Irish Sea, Norwegian fjords, between 50 and 470 m (Salvini-Plawen, 1983, 1997).

**Diagnosis.** Slender, <5 mm long, shiny, epidermal spicules quadrate, foot not within groove, mouth separate from vestibule, without midgut sacculations, with seminal vesicles, without seminal receptacles, paired lower gametoducts either united or joined laterally to anterior extension of mantle cavity, paired copulatory spicules 2 per sac, dorsoterminal sense organ rudimentary above large, granule-filled epidermal cells.

**Remarks.** Species of *Tegulaherpia* were placed provisionally in the Lepidomeniidae on the basis of a thin cuticle with scales, a distichous radula, and what is here called tubular ventral salivary glands (Salvini-Plawen, 1988, as subepithelial-follicular glands). The nominate genus of the family is monotypic, based on the description of a single juvenile individual from the Mediterranean, *L. hystrix*

Marion & Kowalevsky. No Aplacophora has since been attributed either to *L. hystrix* or to the genus *Lepidomenia* with certainty, although six individuals of *L. hystrix* were reported, without description, from the type locality (Swedmark, 1956; Salvini-Plawen, 1985b). Suggested here is that the genus *Tegulaherpia* may be synonymous with *Lepidomenia* based on similarities between the written description and figures of *L. hystrix* (Kowalevsky & Marion, 1887) and those of *T. tasmanica*, described below, which in turn is similar to *T. stimulosa* from the Mediterranean (Salvini-Plawen, 1988).

***Tegulaherpia tasmanica* Salvini-Plawen, 1988**

Figs. 1, 2, 3A,B

*Tegulaherpia* sp.—Scheltema, 1998, fig. 2.8

**Type material.** Holotype (TM, E23218) and paratypes, Tasmanian Museum, Hobart.

**Type locality.** Off northern coast of Tasmania between Burnie and Penguin, 50–55 m.

**Vouchers.** Bass Strait, Australia, 39°48.6'S 146°18.8'E, 82 m (RV *Tangaroa* BSS-S 158 [epibenthic sled], 13.xi.81); MV 83492 (entire alcohol specimen, spicule slide); length 3.6 mm; anterior, midbody, and posterior height 1.0, 0.5, and 0.3 mm, respectively; width 0.3, 0.4, and 0.3 mm; MV 83493 (dissected alcohol specimen; radula, spicule slides).

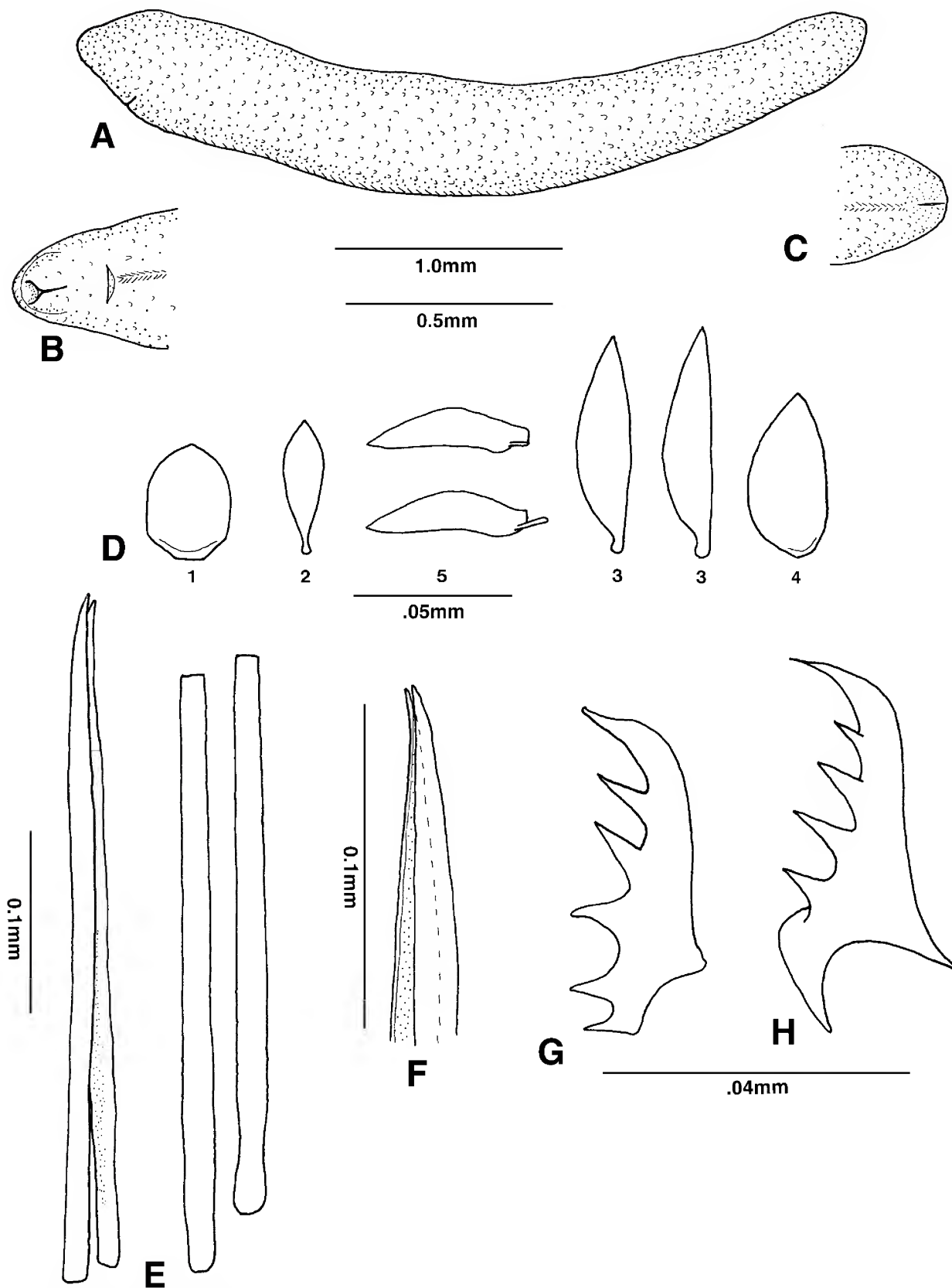
**Material examined.** 22 individuals, including 2 paratypes from off Tasmania and 20 individuals from Bass Strait Survey, RV *Tangaroa*, November 1981: 2, BSS-S 157 (epibenthic sled), 40°10.9'S 145°44.3'E, 75 m; 7, BSS-S 158 (epibenthic sled), 39°48.6'S 146°18.8'E, 82 m; 2, BSS-S 159 (epibenthic sled), 39°46.0'S 146°18.0'E, 80 m; 1, BSS-G 159 (Smith-MacIntyre grab), 39°43.5'S 146°18.8'E, 80 m; 5, BSS-S 165 (epibenthic sled), 40°13.8'S 148°39.6'E, 60 m; 3, BSS-S 169 (epibenthic sled), 39°02.4'S 148°30.6'E, 120 m.

**Description.** Up to 3.7 mm long, greatest height anterior, to 1.0 mm, tapered posteriorly, posterior height to 0.4 mm, somewhat compressed laterally, midbody height to 0.7 mm, width to 0.5 mm, anterior end rostrate, posterior end somewhat pointed to rounded, ventral line indicated by erect spicules on each side of foot (Figs. 1A, 3A); contracted mouth opening Y-shaped with a small knob in fork of the Y; contracted pedal pit opening distinct, laterally slit-shaped (Fig. 1B); mantle cavity opening terminal (Fig. 1C), dorsoterminal sense organ not externally obvious. Cuticle thinner than epidermis, 5 and 10 µm, respectively; epidermis with thickset, heavily granulated papillae. Epidermal spicules about 1 µm thick, of four types, all with small, sharp distal point; most numerous spicules quadrate (Fig. 1, spicule D1), widest at base, base laterally concave and medially straight, to 42 µm long by 29 µm wide; type 2 (spicule D2) short, symmetrical paddles to 42 µm long by

14 µm wide, ending basally in a small knob; type 3 (spicules D3) large, asymmetrical paddles, convex on one side, flat to slightly convex on the other, with basal knob, to 75 µm long by 15 µm wide; and type 4 (spicule D4) large, asymmetrical ovoid spicules lateral to foot spicules, base narrow, straight, to 57 µm long by 26 µm wide; variation within each spicule type slight; spicules from beside foot (spicules D5) both with and without narrow handle on truncated base, spicule convex next to handle, becoming concave distally, convex on opposite side, to 52 by 15 µm not including handle. Radula (2 examined) with about 15 rows; teeth with 4 median denticles and distal hook, base produced into additional denticle-like protuberance, to 53 µm long (Figs. 1G,H, 3B). Copulatory spicules examined from one individual with 2 long, slender spicules of about equal length per sac, one fitting into a groove in the other, sharply pointed and slightly curved distally, proximally rounded and, in one of the two spicules, slightly bulbous; 700 µm long, greatest width 20 µm (Fig. 1E,F).

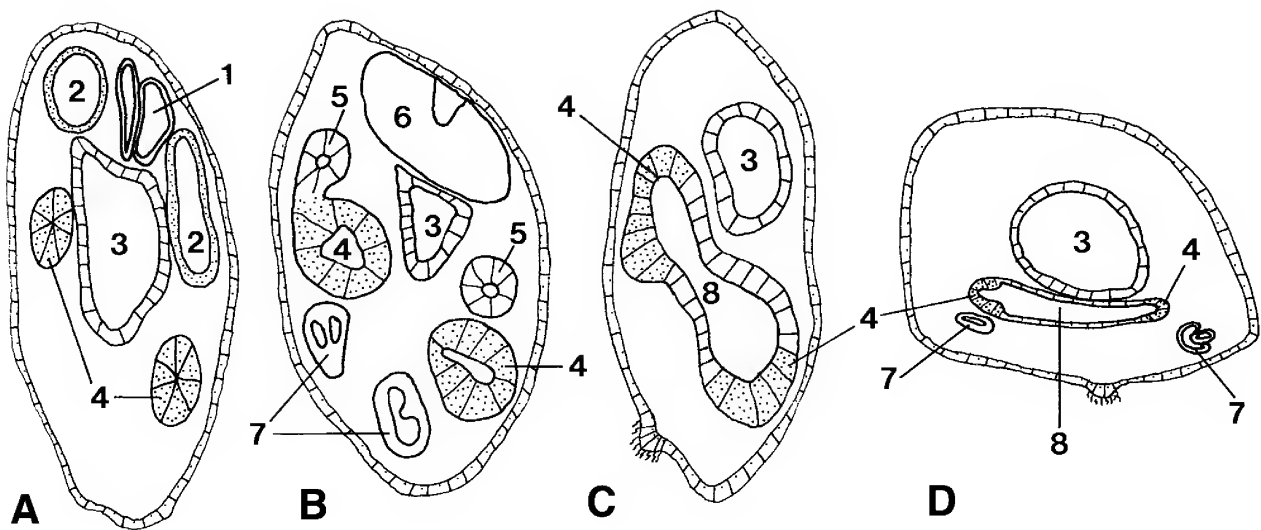
**Reproductive system.** *Tegulaherpia tasmanica*, like *T. stimulosa*, has paired seminal vesicles opening off the anterior end of the gonopericardial ducts but no seminal receptacles (Fig. 2A,B). The lower gametoducts remain paired, opening laterally onto a dorsoventrally compressed tubular extension of the mantle cavity, as indicated by cell contents (Fig. 2C,D); further posteriorly the epithelium of the gametoducts joins ventrally but not dorsally. Copulatory spicules are formed before maturation of gonad primordium in juveniles (Fig. 2D).

**Remarks.** The illustrated description here expands the original written diagnosis of the species (Salvini-Plawen, 1988); identifications were made by comparisons with paratype material. For differences between *Tegulaherpia tasmanica* and the two other *Tegulaherpia* species, *T. stimulosa* and *T. myodoryata* Salvini-Plawen, I have relied on the original descriptions. In body shape, the anterior end of *T. tasmanica* is pointed, not rounded (cf. Figs. 1A, 3A with Salvini-Plawen, 1988, figs. 7, 8). The description of *T. stimulosa* from the Mediterranean, which *T. tasmanica* most closely resembles, does not include illustrations of all types of epidermal spicules or the copulatory spicules. According to the written description, in *T. stimulosa* the spicules from beside the foot are smaller and pedal glands less distinct than I observed in *T. tasmanica*, and ducts of the salivary glands are ampulla shaped, rather than tubular as in *T. tasmanica*. According to the written description of *T. tasmanica* (Salvini-Plawen, 1988, p. 385) there are anatomical differences between the two species in the relationships of the rectum and copulatory spicule sheaths and their openings into the mantle cavity. The statement that there is an unpaired portion of the lower gametoduct longer than in *T. stimulosa*, however, is not in accord with my observations, that the lower gametoducts remain paired and open laterally onto an extension of the mantle cavity (Fig. 2C,D). It is perhaps the mantle cavity extension that is longer in *T. tasmanica*.



**Figure 1.** *Tegulaherpia tasmanica* Salvini-Plawen. A–C, voucher specimen (MV 83492): A, anterior to left, upper scale; B, C, ventral views of anterior and posterior ends, respectively, lower scale. D, epidermal spicules of A, types 1–5. E, F, copulatory spicules, basal portions to right in E broken off from pointed distal portions to left; stippling indicates groove. G, H, oldest and second newest radular teeth. E–H from dissected voucher specimen (MV 83493).





**Figure 2.** *Tegulaherpia tasmanica* Salvini-Plawen, reproductive system; semischematic drawings of sectioned material. A–C, mature individual from same location as voucher specimen. D, paratype, immature individual. Foot indicated in C and D only; missing copulatory spicule sacs in section C an artifact of sectioning. 1 gonopericardial duct, 2 seminal vesicle, 3 intestine, 4 lower gametoduct (blind ends shown in section A), 5 upper gametoduct, 6 pericardium with heart, 7 copulatory spicule sac, 8 anterior extension of mantle cavity.

#### Family incertae sedis

##### *Ocheyoherpia* Salvini-Plawen, 1978

**Type species.** *Ocheyoherpia lituifera* Salvini-Plawen, 1978, by monotypy.

***Ocheyoherpia* distribution.** Off subantarctic islands (South Sandwich, South Shetland, and South Georgia) at depths less than 250 m; Macquarie Island at less than 15 m depth.

**Diagnosis.** Thick-bodied, small neomenioids with solid epidermal spicules in the form of spines, barbed spicules, and serrated spicules; skeletal spicules lacking; cuticle thick or thin; with two pairs of pharyngeal salivary glands, one of them acinar; radular teeth with several denticles on a bar incompletely attached to radular membrane, outer denticles fused to a curved process swung from beneath tooth base; dorsal midgut coecum paired; midgut sacculate; copulatory spicules 2 or more per pair; paired seminal receptacles and accessory copulatory glands present; gametopore single; respiratory folds low, few; dorsoterminal sense organ absent.

**Remarks.** Assignment of the genus *Ocheyoherpia* to the Phyllomeniidae (Salvini-Plawen, 1978) seems untenable on these grounds: (a) *Ocheyoherpia* spp. do not have true gametoducts as uniquely held by species of *Phyllomenia* (Salvini-Plawen, 1978); (b) both barbed epidermal spicules and spines are solid and, in contradistinction to the original description and unlike Phyllomeniidae, skeletal spicules are lacking (Fig. 3D); and (c) the radular teeth have the form of a bar with denticles, unlike the distichous hooks of Phyllomeniidae.

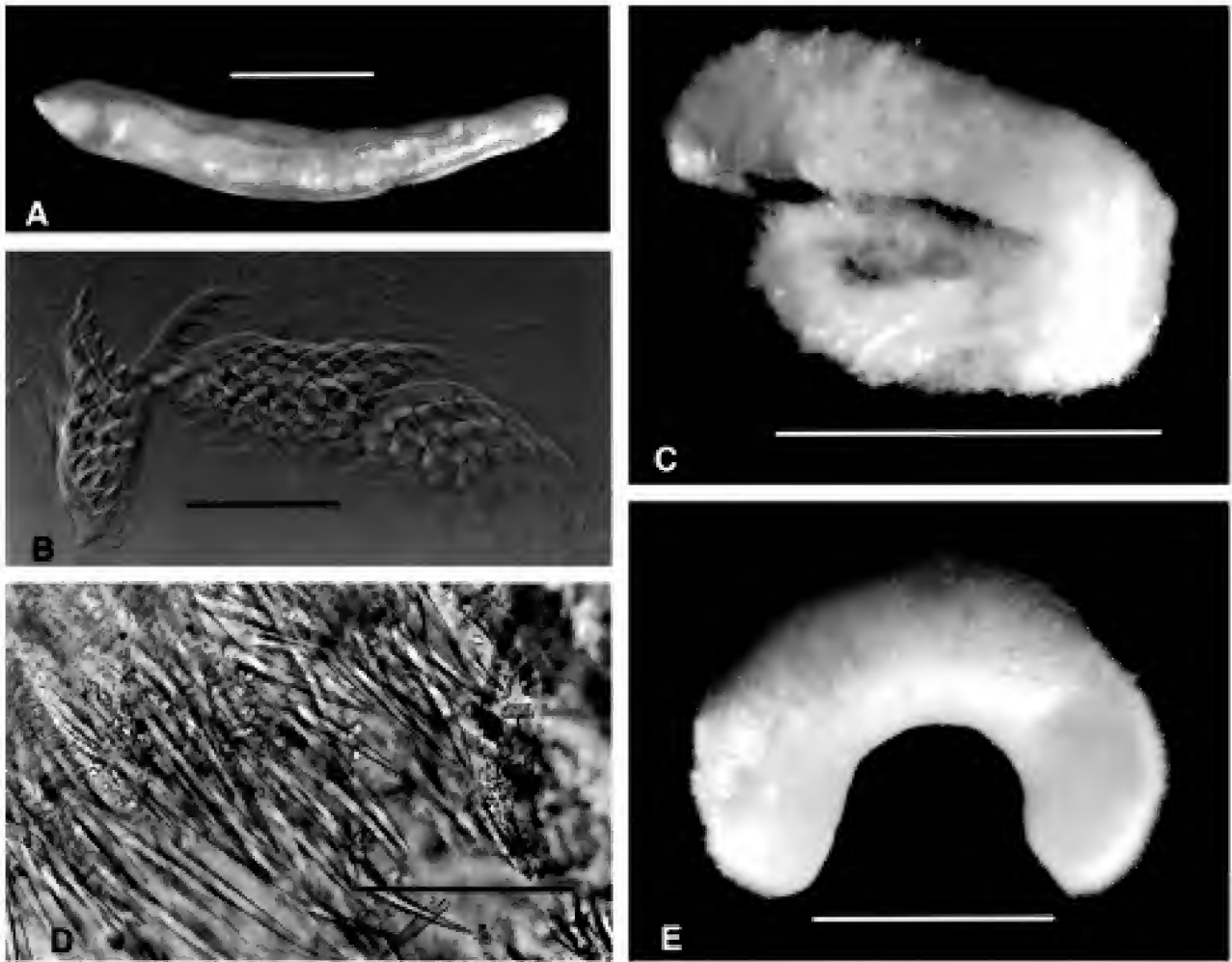
##### *Ocheyoherpia lituifera* Salvini-Plawen, 1978

Figs. 3C, 5A,B

**Type material.** HOLOTYPE: USNM 749738 (alcohol specimen, spicule slide). 3.7 mm long, midbody height 0.7 mm. PARATYPE: USNM 749739 (histologic sections); off South Shetland Island, 62°41'S 54°43'W, 210–220 m (U.S. Antarctic Res. Pgm. stn 12-1003, 15.iii.64).

**Type locality.** Off South Sandwich Island, 56°19'–20'S 27°28'–29'W, 148–201 m (U.S. Antarctic Res. Pgm. 1961–1972, stn 22-1581, 6.iii.1966).

**Diagnosis.** Spiny (Fig. 3C) (see also Salvini-Plawen, 1978, fig. 288), cuticle thick (56 µm), epidermis thin (22 µm); spinelike epidermal spicules thick, long and wide, many greater than 160 µm long and up to 16 µm wide with an untapered, flat base (Fig. 5A); barbs to 170 by 14 µm; distally serrated spicules to 225 µm (see Salvini-Plawen, 1978, fig. 92); short scimitar-like spicules common. Radular teeth approximately 40 µm in length, tips of lateral, fused denticles curved in histologic sections (Fig. 5B). Form of copulatory spicules not known.



**Figure 3.** A, B, *Tegulaherpia tasmanica* Salvini-Plawen: A, voucher specimen (MV 83492); B, distichous radula from a Bass Strait individual (RV *Tangaroa* BSS-S 165). C, *Ocheyoherpia lituifera* Salvini-Plawen, holotype, with mantle cavity partially open (USNM 749738). D, E, *Ocheyoherpia trachia* n.sp.: D, epidermal spicules viewed from beneath cuticle; upright spicules only, without skeletal spicules; E, holotype (AM C203646). Anterior to left, dorsal above in A, C, E.

***Ocheyoherpia trachia* n.sp.**

Figs. 3D,E, 4, 5C–F

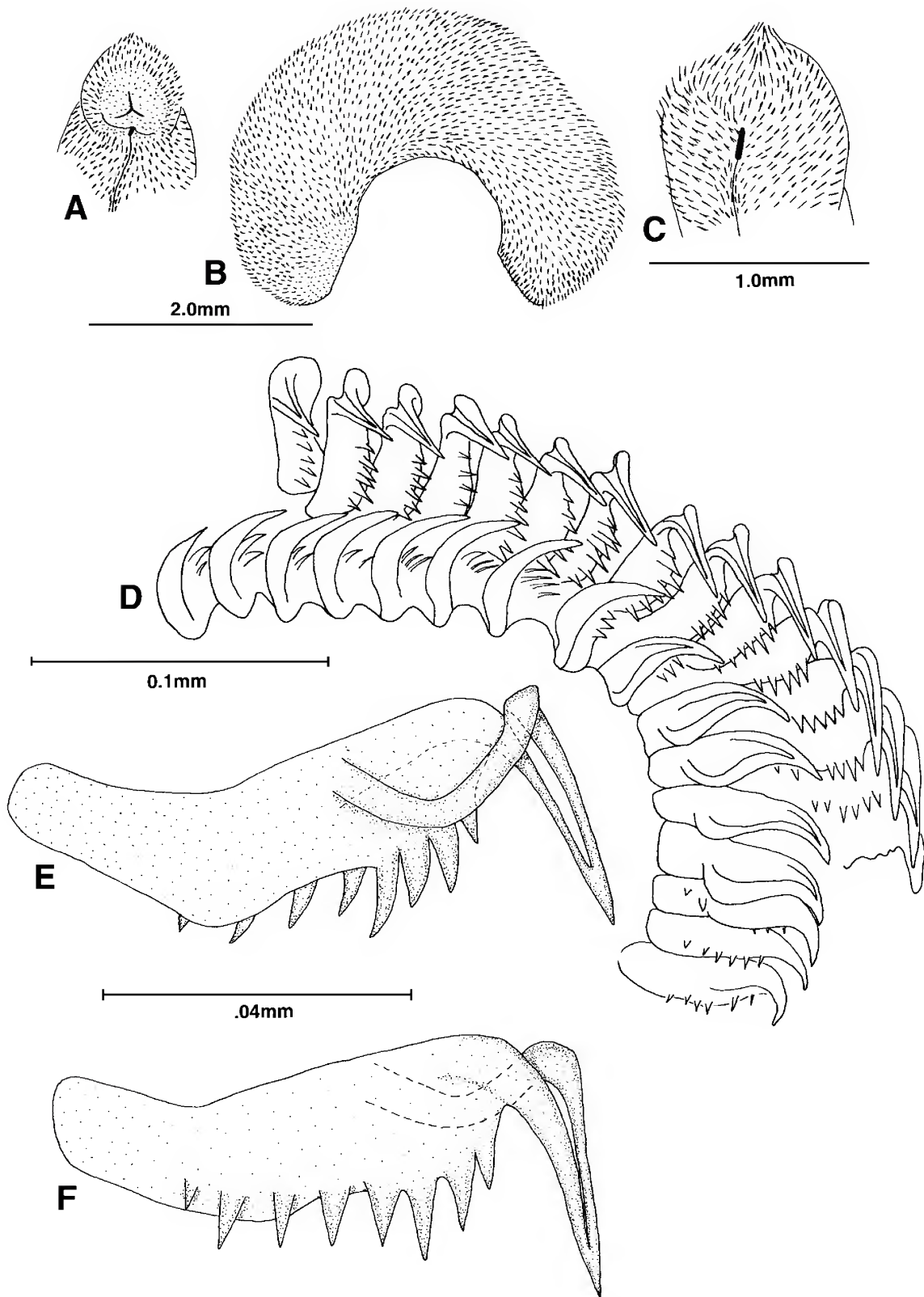
*Ocheyoherpia* sp.—Scheltema *et al.*, 1994, figs. 8A,C, 20G; Scheltema, 1998, fig. 2.15.

**Type material.** HOLOTYPE: AM C203646 (alcohol specimen, spicule slide); length 5.4 mm, anterior, midbody, and posterior height 1.1 mm. PARATYPES (21): AM C203647 (dissected alcohol specimen, radula slide, epidermal and copulatory spicule slides), type locality; AM C203648 (dissected alcohol specimen), type locality. A further 19 paratypes from Macquarie Island Expedition not dissected: 3, Green Gorge Reef, vertical rock wall, 6.1 m (stn MA-275, 54°38'S 158°55'E, AM C149632); 12, rocks, Garden Bay Peninsula, 11 m (AM C149633, type locality); 2, Green Gorge, boulders on sand-gravel

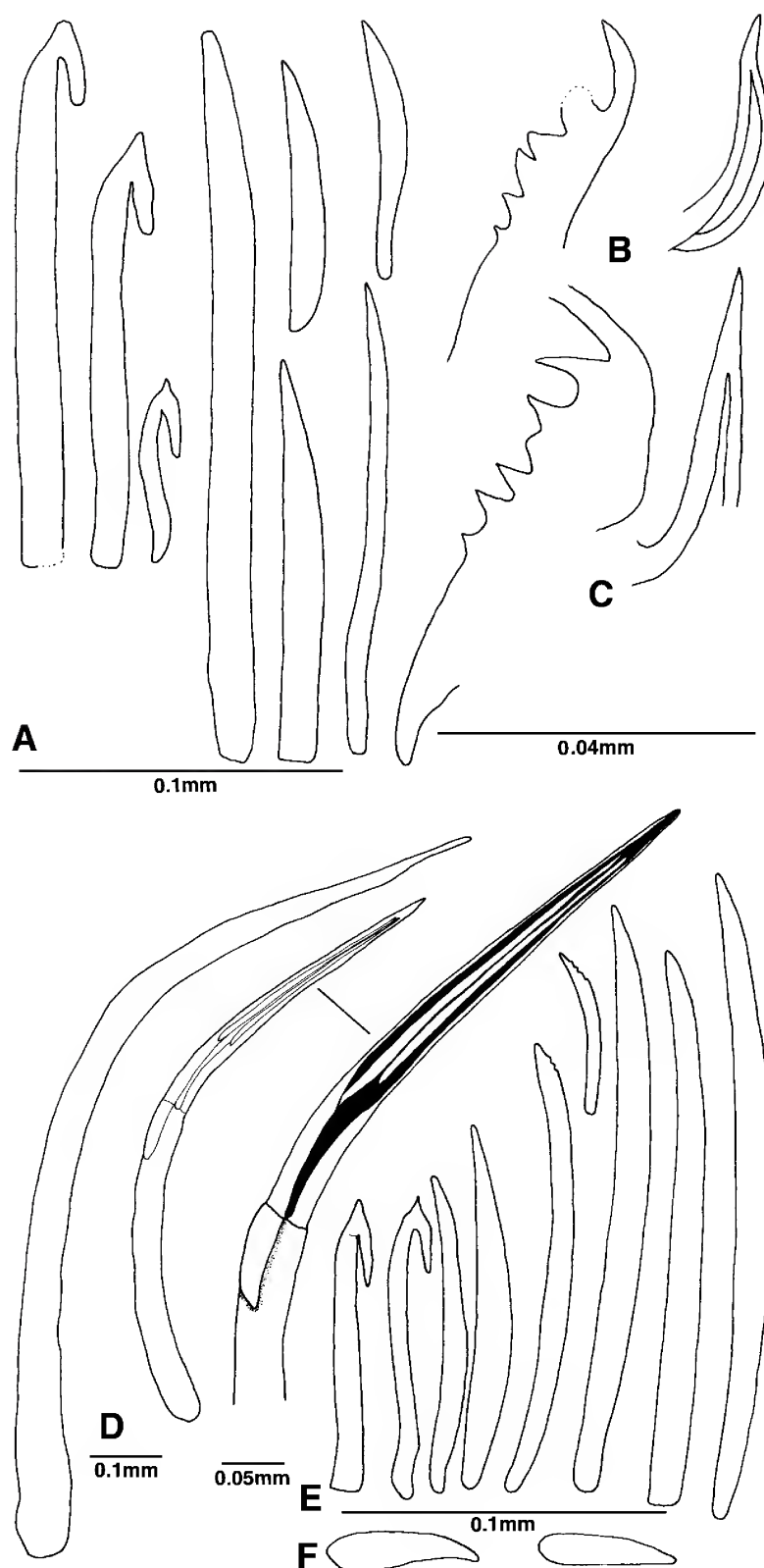
bottom, 14 m (stn MA-245, 54°38'S 158°55'E, AM C149634); 1, off Garden Bay Peninsula, rocks, 11–14 m (stn MA-128, 54°30'S 158°57'E, AM C149635); 1, Green Gorge, boulders on sand and gravel bottom, 13.7 m (stn MA-247, 54°38'S 158°55'E, AM C149636) (histologic sections).

**Type locality.** Macquarie Island, from Garden Bay Peninsula, vertical rock face, 11 m (Australia Museum Macquarie Island Expedition 1977–78, stn MA-125, 54°30'S 158°57'E, 16.xii.1977).

**Diagnosis.** Length to 6.5 mm; spicular coat rough, not shiny; with dorsal carina; barbed spicules few; serrated spicules few, anterior only; two deeply curved copulatory spicules per copulatory spicule sac, the shorter one with grooves and ridges on distal half; cuticle thin (22 m).



**Figure 4.** *Ocheyoherpia trachia* n.sp. A–C, holotype (AM C203646): A, anteroventral end with flattened mouth area stippled, dorsal carina evident. B, entire specimen, anterior to left. C, posteroventral end. D–F, radula of paratype (AM C203647): D, entire radula, distal end to left; one tooth missing, right row. E, single tooth viewed from beneath radular membrane showing supporting bar fused to lateralmost denticle. F, same tooth as if viewed from above.



**Figure 5.** A, *Ocheyoherpia lituifera* Salvini-Plawen, epidermal spicules from holotype; spicules with distal serrations not illustrated. B, *O. lituifera*, radular teeth drawn from sectioned paratype, distal end of fused lateral denticle curved (USNM 749739). C, *Ocheyoherpia trachia* n.sp., radular teeth drawn from sectioned specimen (AM C149636) at same scale as B. D–F, *O. trachia* n.sp., spicules from paratype (AM C203647) except left barbed spicule from paratype (AM C203648); D, copulatory spicules; E, epidermal spicules; F, spicules from beside pedal groove.



**Description.** Spicular coat rough; anterior and posterior ends of body not tapered, flattened ventrally (Figs. 3E, 4B); with dorsal carina; retracted mouth slit an inverted Y-shape, opening of mantle cavity axial, short (Fig. 4A,C); body length to 6.5 mm, height even throughout, to 1.4 mm. Epidermis and cuticle thin, to 18  $\mu\text{m}$  and 22  $\mu\text{m}$ , respectively. Epidermal spicules evenly curved, to 210  $\mu\text{m}$  long by 14  $\mu\text{m}$  wide and more than 10  $\mu\text{m}$  thick, bluntly pointed distally, base slightly tapered with end rounded to straight (Fig. 5E); serrated spicules few, from anterior body only, especially near mouth; few spicules with recurved base; barbed spicules to 128  $\mu\text{m}$  long by 9  $\mu\text{m}$  wide, not numerous; spicules from beside pedal groove nearly ovate but tapered and often curved proximally (Fig. 5F). Radula (3 examined) with about 16 rows of teeth (Fig. 4D); tooth base about 75 by 18  $\mu\text{m}$ , medial one-third attached to radular membrane, number of denticles 7 to 9 excluding lateral fused denticles (Fig. 4E,F); radula ending distally in two lateral pouches of pharynx. Copulatory spicules (1 specimen examined) deeply curved, two per copulatory spicule sac, 1.3 mm and 0.9 mm long, curve nearly 90° (Fig. 5D); longer spicule simple, shorter spicule with ridges and processes on distal half.

**Reproductive system.** The reproductive system and copulatory apparatus follows that of *O. lituifera* (Salvini-Plawen, 1978, figs. 95, 96) with these exceptions: (a) There are paired, large seminal vesicles opening off the ducts leading from the gonads to the pericardium (gonopericardioducts). (b) The paired copulatory glands, voluminous proximally and ending in narrow tubes as in *O. lituifera*, open into the grooved and ridged distal end of the ventral, smaller copulatory spicule shown in Fig. 5D and not into a triangular tube formed by 3 small copulatory spicules as in *O. lituifera*. (c) The copulatory spicules are deeply curved, not nearly straight as illustrated for *O. lituifera*. (d) One pair of copulatory spicules (the smaller?) opens into the mantle cavity on papillae (the sections were too poor in this area to ascertain where the second pair of copulatory spicules end).

**Remarks.** Besides the differences in the reproductive system noted above, *Ocheyoherpia trachia* differs from *O. lituifera* in being less spiny and in having a carina, a large dorsal sinus, a thinner cuticle, narrower and shorter epidermal spicules, fewer barbed spicules, and a larger radula (Fig. 5B,C).

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***Pilbarophreatoicus platyarthricus* n.gen., n.sp.**  
**(Isopoda: Phreatoicidea: Amphisopodidae)**  
**from the Pilbara Region of Western Australia**

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**ABSTRACT.** *Pilbarophreatoicus platyarthricus*, a subterranean phreatoicidean isopod from an intermittent stream in the arid Pilbara region of northwestern Western Australia, is described. With subterranean morphofacies, namely slender vermiform body, eyeless, anteroventral lobe on pereonite 1, reduced abdominal epimera, clearly demarcated pleotelson and lacking in pigment, the species is distinguished particularly by details of the pleotelson. *Pilbarophreatoicus platyarthricus* is a Gondwanan relic surviving in an aquifer in a region with marked surface aridity. Discovery of *P. platyarthricus* highlights the importance of groundwater as a reservoir of biological diversity.

KNOTT, BRENTON, & STUART A. HALSE, 1999. *Pilbarophreatoicus platyarthricus* n.gen., n.sp. (Isopoda: Phreatoicidea: Amphisopodidae) from the Pilbara region of Western Australia. *Records of the Australian Museum* 51(1): 33–42.

The Phreatoicidea are ancient isopods, constituting the earliest derived members (Brusca & Wilson, 1991) and having the longest known fossil record of all living isopods. Their fossil record dates from the Essex fossil beds at Mazon Creek, Illinois, USA, of the Upper Carboniferous (Schram, 1970). Pre-Triassic representatives are known from marine deposits in the Northern Hemisphere (Birstein, 1962; Glaessner & Malzhan, 1962) but their post-Triassic record is exclusively from fresh waters of several of the Gondwanan fragments (Australia, New Zealand and South Africa), with maximum species diversity and abundance in the Bassian zoogeographic province of southern Australia (Knott, 1975). Phreatoicidean diversity in northern, by

comparison with that of southern, Australia seems much reduced with the only records, until recently, from the South Alligator River area of the Northern Territory (Nicholls, 1943; Knott, 1975). However, information about the groundwater fauna of north-western Australia is increasing and more phreatoicideans are being found. *Crenisopus acinifer*, from a freshwater spring in the Kimberley region of Western Australia, was described by Wilson & Keable (in press). In addition, Wilson & Ponder (1992) described two species of *Tainisopus* from a cave pool and a spring outflow in the Kimberley that resembled phreatoicoideans, although they were not assigned to a currently described isopod suborder or family.

Annual rainfall in southern Australian sites, on the South Alligator River and at Kimberley sites where phreatoicids have been collected is comparatively high (600–1,000 mm). The discovery of a new phreatoicid from an intermittent stream in the arid Pilbara region (annual rainfall <300 mm) is biogeographically significant. This paper provides a description of the new species, for which a new genus is described, and highlights the zoological importance of groundwater in arid areas.

### Family AMPHISOPODIDAE Nicholls, 1943

#### *Pilbarophreatoicus* n.gen.

**Type species.** *Pilbarophreatoicus platyarthricus* n.sp. by monotypy

**Diagnosis.** Body slender, vermiform, smooth dorsally with scattered setae. Head longer than deep, with sub-antennary lobe lacking incisure on anterior margin; eyes absent; mandible placed anteriorly; cervical groove weakly developed. Pereonite 1 free from the head with anteroventral lobe prominent and overlapping head; pereonites 3 and 4 longest, pereonites 5–7 short but deeper than other pereonites; epimera of pleonites 1–5 short; pleotelson long, emarginate and not upturned, telsonic pleura broadly bilobed. Left and right mandibles with *lacinia mobilis*, gnathopod with oblique palm and two strong buttresses, mid-appendage articles (particularly the merus) of pereopods 2–4 broadly expanded; pleopods without epipodites. Uropods robust, distal corner of upper margins marked by stout simple seta and with simple seta below insertion of endopod and exopod, which both terminate in one robust seta; exopod rotated to lie below endopod.

**Etymology.** The generic name is derived from the Greek *phreatoic*, meaning well-dweller, and from Pilbara, referring to the geographical area where the specimens were collected. Gender: masculine.

**Remarks.** Hypogean phreatoicids are known from all three extant families (Amphisopodidae, Nicholliidae, Phreatoicidae) (Nicholls, 1943, 1944; Tiwari, 1955). *Pilbarophreatoicus platyarthricus* clearly belongs to the lineage retaining a *lacinia mobilis* on both left and right mandibles (Amphisopodidae and Nicholliidae) but lacks elongate uropodal exopods and cleft pleopodal endopods, which are characteristic of males of species of Nicholliidae (recorded only from deep wells in a small area of the Gangetic Plain between Varanasi and Patna in India) (Tiwari, 1955). *Pilbarophreatoicus platyarthricus* is therefore assigned to the family Amphisopodidae.

#### *Pilbarophreatoicus platyarthricus* n.sp.

Figs. 1–6

**Type material.** HOLOTYPE: male, 12 mm, partially dissected with appendages on 2 slides, Western Australian Museum of Natural Science WAM C 23241, Nyeetberry Pool (21°51.6'S 116°30.7'E by GPS) on Jimmawurrada Creek, tributary of Robe River, Pilbara, 2 May 1995, W.R. Kay & M.R. Smith. PARATYPES: 2 juveniles, WAM C 23242, same location, 2 May 1995, W.R. Kay & M.R. Smith. 3 juveniles, WAM C 23243, same location, W.R. Kay & M.R. Smith, 11 May 1996.

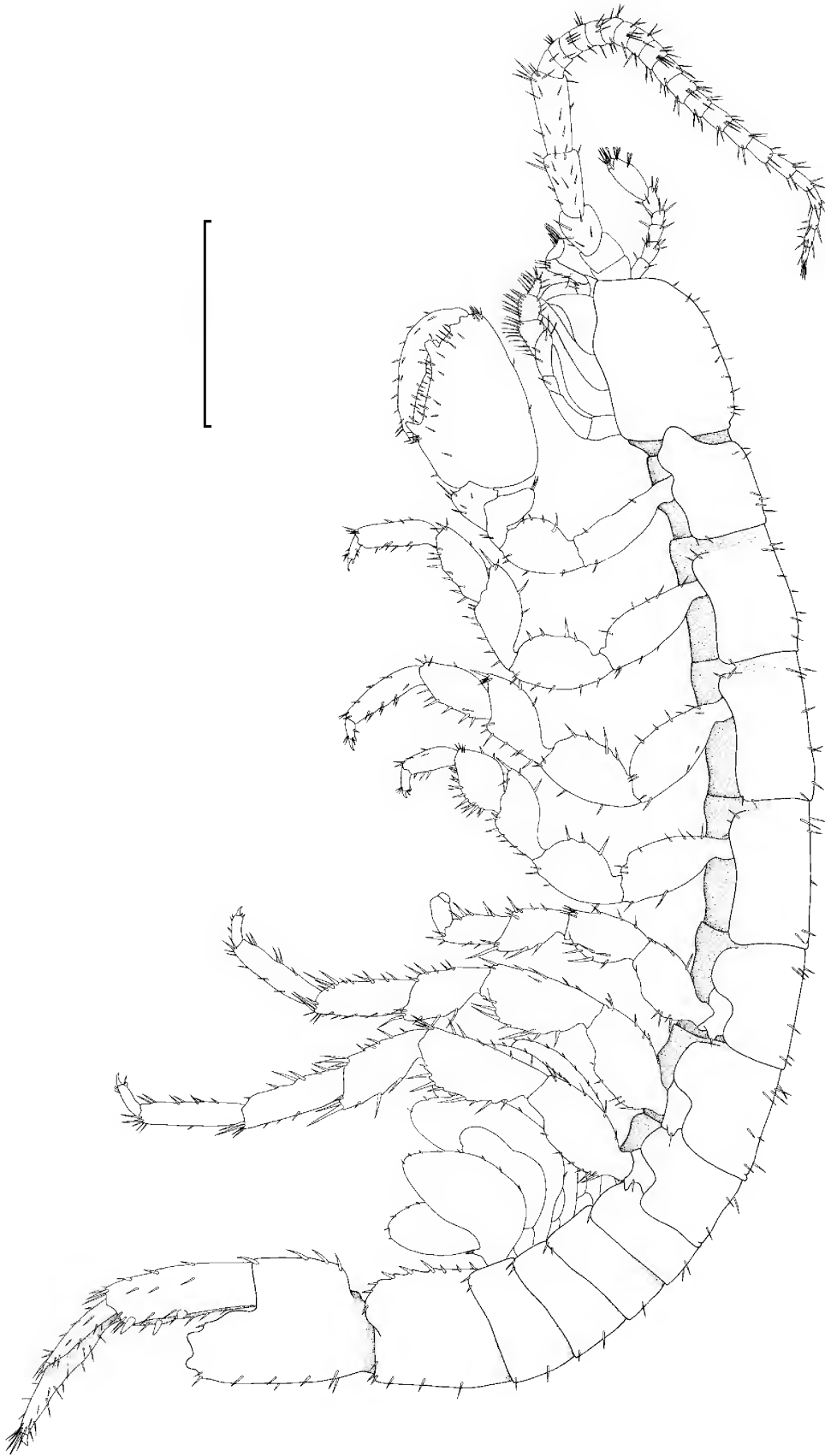
**Additional material examined:** 5 males (7.4–11.4 mm long), 10 females (5.7–7.7 mm), 2 juveniles (5.3, 5.7 mm), WAM C 24156, Chalyarn Pool, Robe River (21°45.2'S 116°02.1'E, ≈50 km E of Nyeetberry Pool), 18 April 1998, J.M. McRae. 1 male, 1 female, Australian Museum P 53154, Chalyarn Pool, 18 April 1998, J.M. McRae.

**Description of holotype male.** Body (Fig. 1) slender, attenuated with parallel sides, smooth with scattered short setules dorsally, particularly on the anterior margins of thoracomeres 2–5; lacking pigment in 70% ethanol.

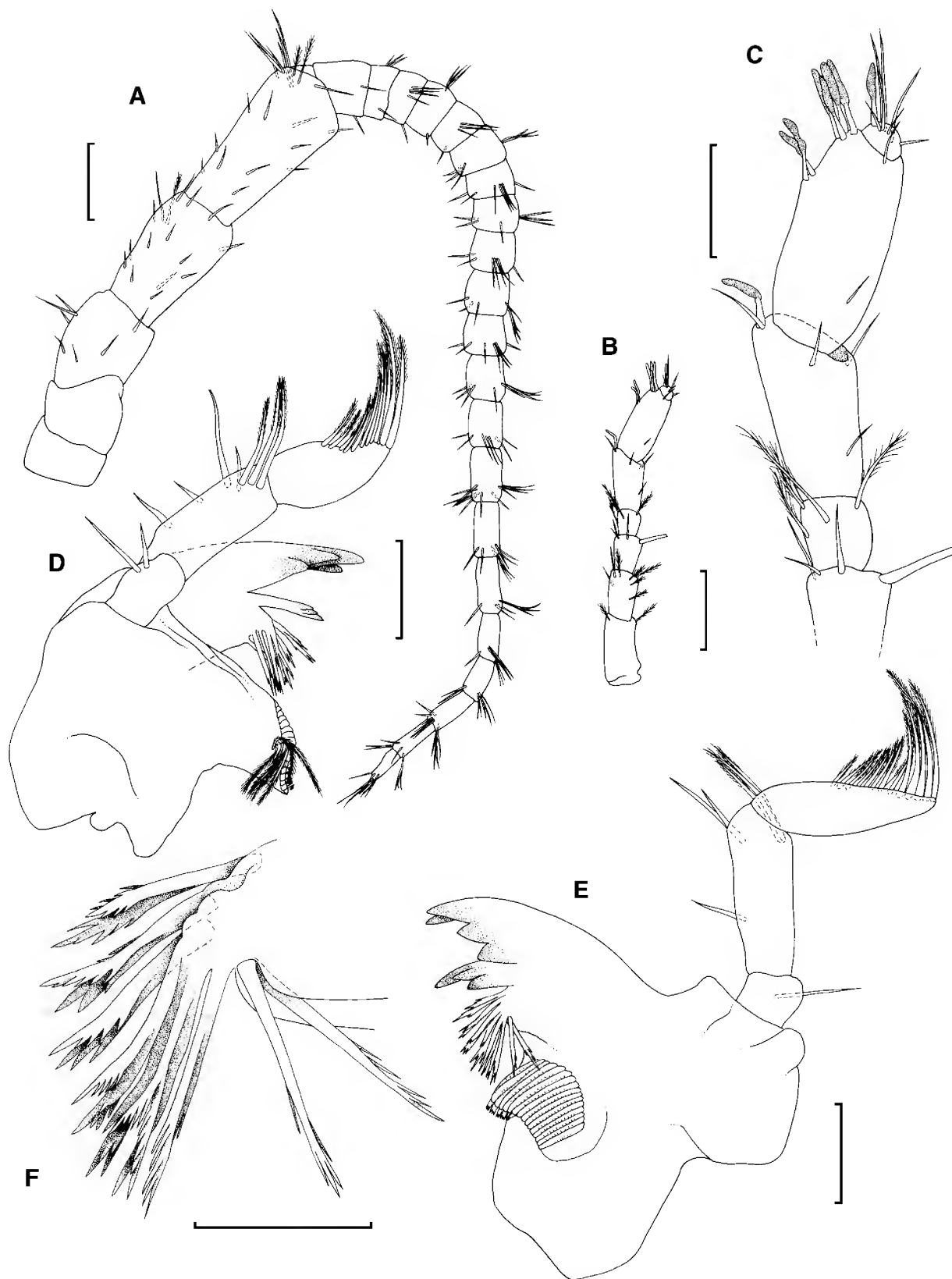
Head longer than deep; cervical groove weakly developed; prominent sub-antennary lobe lacking incisure on anterior margin; ventral margin slightly concave along line of articulation with mandible and also over remaining mouthparts; eyeless.

Antenna 1 (Fig. 2) short, reaching to base of peduncle article 5 of antenna 2; with 7 articles, 1–4 decreasing in length, 5 just shorter than 1, 6 longest and widest, 7 shortest; aesthetascs single on articles 7 and 5, clumped on 6; plumose setae on articles 2 (predominantly) and 1, large seta on 3. Antenna 2 (Fig. 2) peduncle with 5 articles, 3–5 being particularly setose; flagellum of 21 articles, each bearing setae sub-terminally. Upper lip (Fig. 3) slightly asymmetrical. Both mandibles stout and with triturative molar process. Left mandible (Fig. 2) incisor process with 4 teeth; *lacinia mobilis* with 3 teeth; spine row of 5 denticulate and several simple spines; molar process with convex grinding surface, armed with 3 plumose setae and 1 simple seta; palp of 3 articles, 1 shortest, 2 (rectangular) and 3 (ensate) approximately equal in length along the midline; palp article 1 with 2 setae, 2 with 3 prominent bipectinate setae distolaterally and row of setae mesially, 3 with sub-apical plumose setae extending to apical brush of long setae. Right mandible (Fig. 2) incisor process with 4 robust teeth; *lacinia mobilis* well developed with 3 teeth; spine row with 8 denticulate setae; molar process prominent and with concave triturating surface; palp similar to that of left mandible. Lower lip (Fig. 3) bilobed, setae apically and mesially. Maxilla 1 (Fig. 3) endopod with 4 long and 1 short plumose apical setae, mesial margin lined with row of short setae; exopod with 13 stout teeth apically, lacking palp. Maxilla 2 (Fig. 3) exopod bilobed, each lobe armed apically with a row of long pectinate setae; endopod with two rows of long seto-spines, simple and pectinate, on apical and mesial margins. Maxilliped (Fig. 3) endopod long and narrow, with pectinate setae along the distolateral and apical margins;

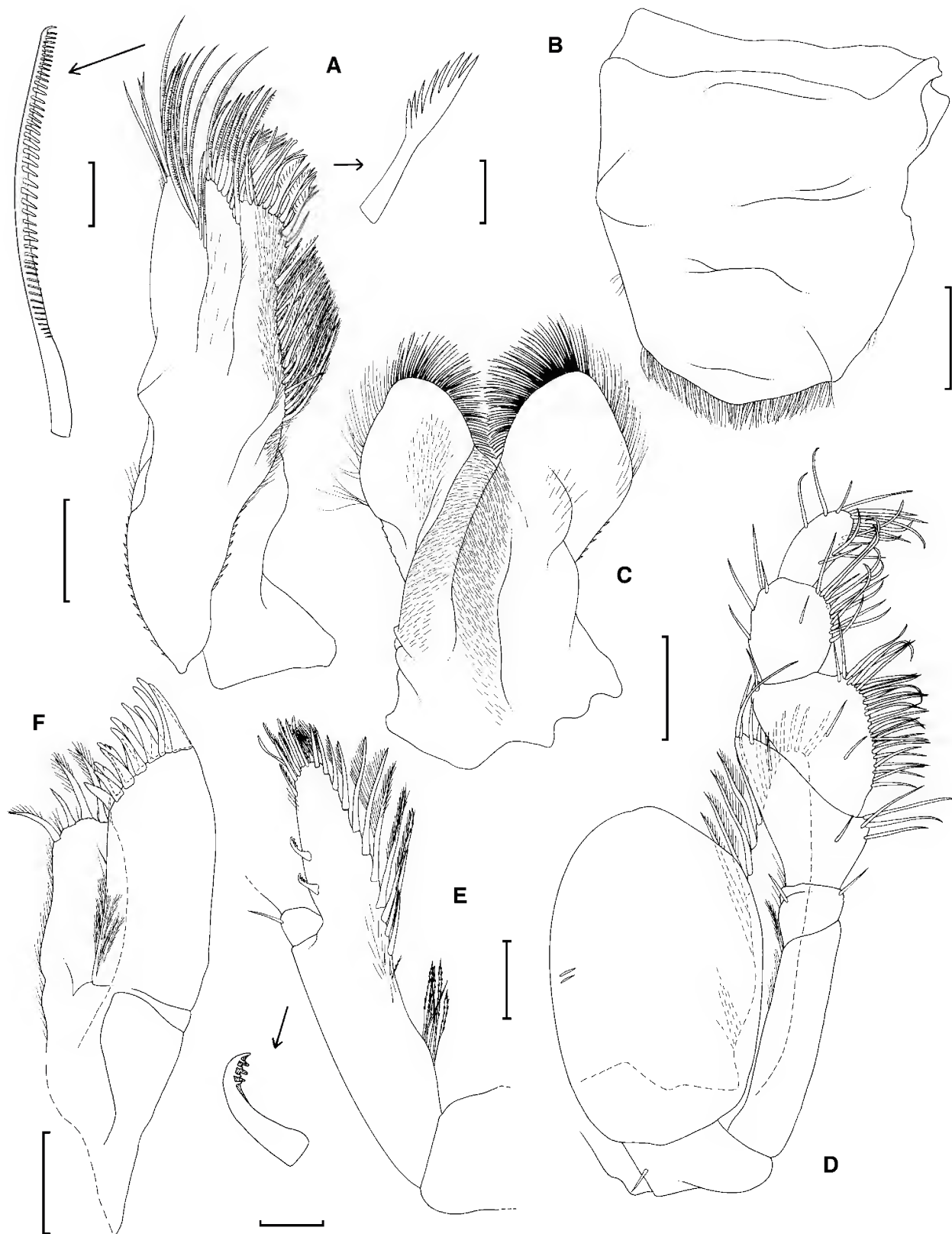




**Figure 1.** *Pilbarophreatoicus platyarthricus*, holotype male, lateral view, scale = 1 mm. Whole animal.



**Figure 2.** *Pilbarophreatoicus platyarthricus*, holotype male. A, left antenna 2. B, left antenna 1. C, detail of aesthetascs on antenna 1. D, left mandible. E, right mandible. F, spine row of right mandible. A, B scale = 0.2 mm, C–E scale = 0.1 mm; F scale = 0.05 mm.



**Figure 3.** *Pilbarophreatoicus platyarthricus*, holotype male. A, left maxilla 2, showing detail of two types of setae. B, upper lip. C, lower lip. D, ventral view of maxilliped. E, medial view of maxilliped with detail of seta. F, right maxilla 1. A–F scale = 0.1 mm; A, E enlargements scale = 0.02 mm.

palp of 5 articles, 1 short, 2 expanded laterally, 3 with prominent inner margin lined with row of long setae, 4 and 5 with marginal setae.

Pereonites 3 and 4 longest, 1 and 7 shortest. Tergites of all pereonites longer than deep; when depth to sternite is considered depth of pereonites 1, 6 and 7 just greater than length, length of pereonites 2–5 greater than depth. Pereonite 1, free from head, anterior margin of tergite expanded ventrally into pronounced lobe overlapping head. Ventral margins of pereonites 2–4 slightly concave between small lobes at anterior and posterior corners of each body segment; pereonites 5–7, convex anteriorly and strongly concave along junction with coxa. Sternites of pereonites 5–7 with prominent midventral protuberance. Coxae 1–4 are inserted anteriorly on pereonite, coxae 5–7 are inserted on posterior half of the respective pereonite. Coxae 1–4 immovable, 5–7 movable with a seta on the posterior lobe.

Gnathopod (Fig. 4) with basis not expanded, ischium expanded anteriorly, merus expanded anteriorly and buttressing against enlarged propodus, carpus small and articulating with the posterior margin of propodus; propodus longer than wide with an oblique, crenulated palm delineated distally by prominent buttress and proximally by a large spur; on each side of palm are two rows of setae, dactylus has dagger-shaped terminal section carrying 2 setae. Pereopods 2 and 3 (Fig. 4) similar, ischium expanded anteriorly, merus with prominent anterodistal expansion, dactylus bearing secondary unguis. Pereopod 4 (Fig. 4) with broadened carpus with row of spines on posterior margin, dactylus with 2 pegs. Pereopods 5 and 6 (Fig. 4) with anterior margin of basis curved convexly, posterior margin expanded proximally through convex curve and narrowing distally through concave curve; ischium broadly triangular with posterior expansion. Pereopod 7 longest. Margins of all articles, particularly of pereopods 2–7, armed with stout setae. Penis broad, rectangular, unarmed, attached at the coxa/sternite junction; both penes meeting in the midline of the body.

Pleonites 1–6 increasing slightly in depth (Fig. 1). Pleonite 5 is  $>2 \times$  length of each of pleonites 1–4. Epimera short, covering pleopod peduncles; posteroventral lobes bearing 1 or 2 setae; posteroventral lobe and ventral margin of epimeron of pleonite 5 with row of setae. Pleotelson with anterior waist; ventro-lateral margin with 3 marginal and 2 submarginal setae; posteriorly, lateral margins bilobed, dorsal lobe bigger than ventral; posterodorsal margin produced into broad, short pleotelson, which is shallowly and asymmetrically cleft and turned downwards, with several fine setae on margin of cleft. Anus lies at base of tube formed from the pleotelson dorsally and ventrally by a cuticular ridge (Fig. 5).

Pleopods (Fig. 6) biramous with length decreasing from 1 to 5; peduncles arranged nearly transverse to main body axis with mesodistal corner rotated posteriorly. Exopod of pleopod 1 simple, pleopods 2–4 with medial lobe. *Appendix masculinis* of pleopod 2 short and curved, reaching just beyond edge of endopod. Uropod (Fig. 5) peduncle with 3

small setae ventrally, both upper margins lined with setae and large robust seta at distal corner (outer, submarginally); 1 simple seta and several setae ventrally below the insertion of the rami; exopod 2/3 length of endopod, rotated to lie ventral to endopod, which has lateral subterminal setal tuft and terminates in movable seta.

Females. Oostegites on pereonites 1–4 inclusive; differs from male in gnathopod—propodus markedly triangular and palm lacking spine and buttress but with long setae on the lobe; carpal lobe of pereopod 4 lobe not pronounced, spine row less distinct; sternite of only pereonite 7 is prominently ridged; pleopods similar in length.

Juveniles carry same-shaped gnathopods as females.

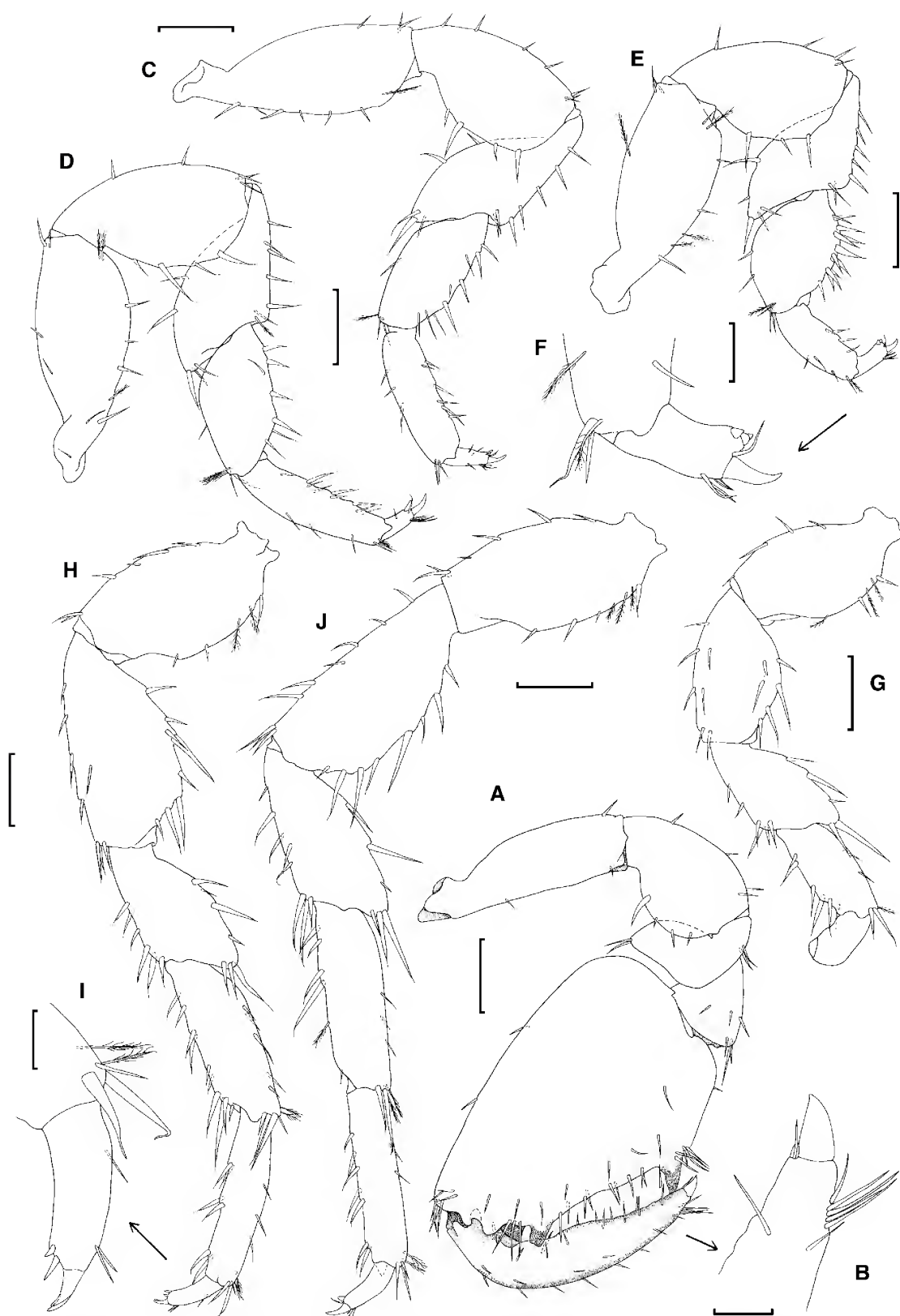
**Etymology.** The name *platyarthricus* is derived from the Greek meaning broad articles, referring to the expanded articles, particularly the merus, of several pereopods.

**Remarks.** Some character variation is evident among specimens from Nyeetberry Pool. For example, in males, number of articles in the flagellum of antenna 2 varies between 18 and 30, and in the 2 specimens with both flagella intact, number on either side differs. Setation is more pronounced in larger specimens, with an anterior line of short setae across each pereonite. Numbers of setae on limb articles and tergites is variable.

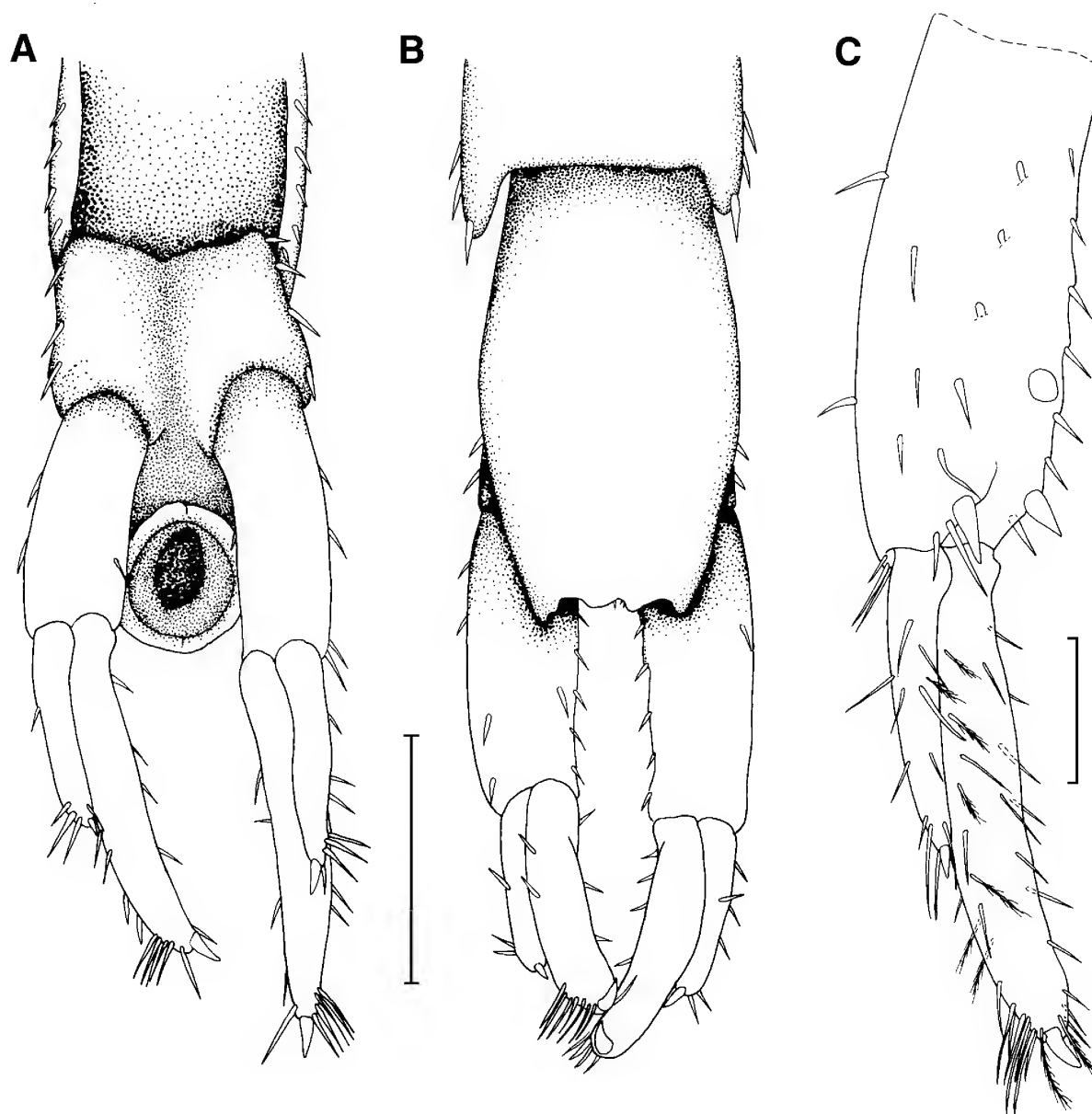
*Pilbarophreaticoicus platyarthricus* is distinguished from other Australian groundwater isopods within the genera *Hyperoedesipus*, *Hypsimitopus* and *Phreaticoides* by robust antennae 1 and 2, two prominent spurs on buttresses on the palm of the gnathopod, degree of expansion of ischium and merus (in *Phreaticoides* only merus is expanded) and, particularly, in details of the pleotelson, which is emarginate (truncated in *Hypsimitopus*) with anus at base of a well defined tube (in other phreaticoideans anus is positioned close to the level of the body surface), broadly bilobed posterolateral margin, and uropod endopods and exopods terminating in movable setae (in *Hyperoedesipus* there is an indication of a terminal seta but it is immovable).

Groundwater phreaticoideans have few characters that indicate relatedness to surface dwelling forms, although Knott (1975) found the condition of the gut, whether with typhlosole and/or gut caecae, to be a reliable indicator of subfamily (*sensu* Nicholls, 1943, 1944) relationships. The faecal strand in the anus of *P. platyarthricus* is round, indicating an alimentary tract lacking a typhlosole; the specimen was not dissected to observe the gut caecae. Members of the Mesamphisopodinae and Amphisopodinae lack a typhlosole and hind gut caecae, whereas at least some representatives of the Hypsimetopinae from southeastern Australia have a typhlosole and numerous, small hind gut caecae. Given the present distribution of the subfamilies Mesamphisopodinae (South Africa, Northern Territory and southern Western Australia) and Amphisopodinae (southern Western Australia and mound springs near Lake Eyre, South Australia), *P. platyarthricus* appears to represent a subterranean invasion of ancestors originally spread across the African/Western Australian region of Gondwana.





**Figure 4.** *Pilbarophreatoicus platyarthricus*, holotype male. A, right gnathopod. B, detail of dactylus of right gnathopod. C, right pereopod 2. D, right pereopod 3. E, right pereopod 4. F, detail of dactylus and unguis of right pereopod 4. G, right pereopod 5, dactylus and unguis regenerating. H, right pereopod 6. I, detail of dactylus and unguis of right pereopod 6. J, right pereopod 7. A, C–E, G, H, J scale = 0.2 mm; B, F, I scale = 0.05 mm.



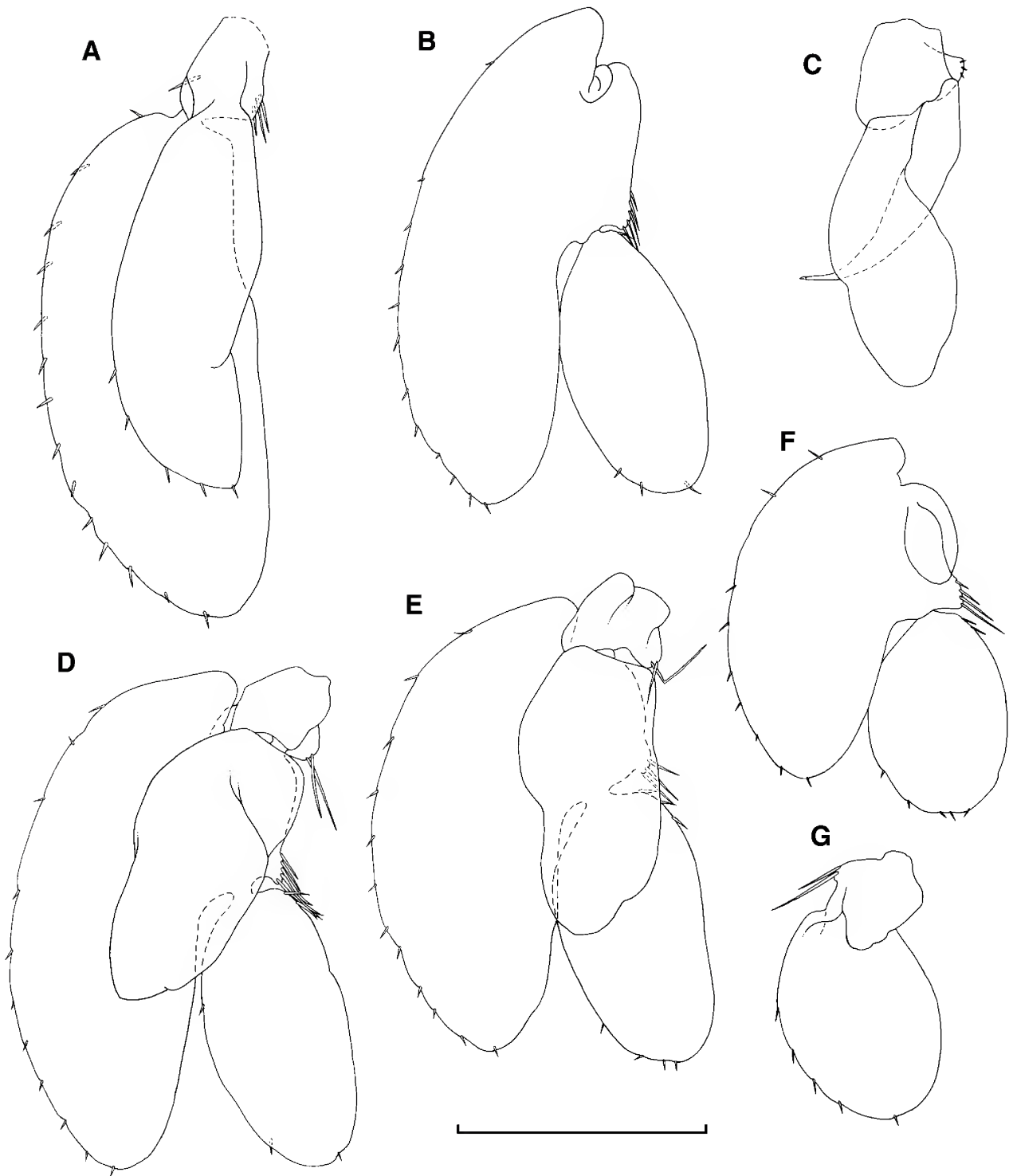
**Figure 5.** *Pilbarophreatoicus platyarthricus*, holotype male. A, pleotelson and uropods, ventral view. B, dorsal view. C, detail of right uropod, lateral view. A, B scale = 0.5 mm; C scale = 0.2 mm.

### Discussion

*Pilbarophreatoicus platyarthricus* was collected from part of the Pilbara with median annual rainfall of about 300 mm and maximum temperatures often exceeding 45°C. All specimens were collected during the wet season (summer/autumn) from under cobbles in slow-flowing riffles in small pools of permanent water, maintained by groundwater discharge, on the Robe River. Other sections of the river, like streams elsewhere in the Pilbara, dry between periods of flow. Water in Nyeetberry Pool was fresh (780  $\mu\text{S}/\text{cm}$  in 1995, 675  $\mu\text{S}/\text{cm}$  in 1996) with alkalinities of 330–320 mg/

L and pH values of 7.8–7.6. Water in Chalyarn Pool was also fresh (1144  $\mu\text{S}/\text{cm}$ ) with pH 7.6 in 1998. Most subterranean phreatoicideans in southern Western Australia occur in freshwater of similar, or slightly higher, salinity (B. Knott, unpublished data).

This is the first account of a phreatoicidean from the Pilbara region of Western Australia. The species was not found during the dry season when, presumably, animals had retreated deeper in the riverbed. The slender vermiform body, lack of eyes and pigment, reduced abdominal epimera, and anteroventral lobe on pereonite 1 are typical of hypogean phreatoicideans (Knott, 1975) and provide



**Figure 6.** *Pilbarophreatoicus platyarthricus*, holotype male. A, right pleopod 1. B, exopod of right pleopod 2. C, endopod of right pleopod 2 with *appendix masculinis*. D, right pleopod 3. E, right pleopod 4. F, exopod of right pleopod 5. G, endopod of right pleopod 5. A–G scale = 0.5 mm.

morphological evidence, in addition to the habitat data, that *Pilbarophreatoicus platyarthricus* lives in groundwater. Its hypogean habits enable survival in an arid environment where surface water may occasionally dry out even in the deepest groundwater-fed pools.

Other relict, ancient freshwater crustaceans have also been recorded from the extensive groundwater reservoirs of the Pilbara (Poore & Humphreys, 1998), which seems to be a region of particular biogeographic importance, although its aquatic fauna is poorly known. Karst systems (Poore &

Humphreys, 1998), peat accumulations associated with outflow points of palaeorivers now flowing predominantly underground (Wyrwoll *et al.*, 1986), and groundwater discharge sites in modern rivers (Kay *et al.*, 1999) are likely to harbour phreatoicoideans which, if their pattern of diversity elsewhere is a reliable guide, are likely to represent monotypic genera, each with limited distribution.

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## Waite's Blind Snakes (Squamata: Scolecophidia: Typhlopidae): Identification of Sources and Correction of Errors

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**ABSTRACT.** The majority of the 542 typhlopoid specimens examined by Edgar Waite for his 1918 monograph of the family are identified, and their current status discussed. Most Waite records that do not correspond with the distribution based on modern records are shown to be in error, involving either misidentifications, misreadings of localities, or transposition of data. A few remaining problematic records are considered dubious due to a lack of supporting data.

*Ramphotyphlops batillus* (Waite, 1894), known only from the holotype from Wagga Wagga, NSW, is restored to the Australian fauna, and new data on the type are provided.

Probable paratypes for *Typhlops grypus* (SAM R849; QM J2947), *T. proximus* (AM R615, R145401–07, SAM R915) and *T. subocularis* (AM R2169) are identified. New data on dorsal scale counts are provided for *Ramphotyphlops leucoproctus* (377–394), *R. polygrammicus* (370–422), *R. proximus* (326–392), *R. wiedii* (381–439) and *R. yirrikalae* (447–450).

SHEA, GLENN M., 1999. Waite's blind snakes (Squamata: Scolecophidia: Typhlopidae): identification of sources and correction of errors. *Records of the Australian Museum* 51(1): 43–56.

Although a number of species of Australian typhlopoid snakes had been described by European herpetologists in the nineteenth century, notably Wilhelm Peters and George Boulenger, it was the publications of Edgar Ravenswood Waite (Waite, 1893, 1894, 1897a,b, 1898, 1917, 1918a), culminating in a revision of the family in Australia (Waite, 1918b), that provided the basis of knowledge of the Australian typhlopoid fauna. In the 80 years since Waite's final revision, despite several new species being described (Parker, 1931; Kinghorn, 1929a, 1942; Loveridge, 1945; Robb, 1972; Storr, 1983, 1984; Ingram & Covacevich, 1993; Aplin & Donnellan, 1993; Shea & Horner, 1997; Aplin, 1998; Couper *et al.*, 1998) only one significant revision of Australian typhlopids has appeared (Storr, 1981). Waite's

work, particularly his key, distribution maps and figures, has been the main source of much of the subsequent literature on Australian typhlopids.

Waite's typhlopoid work set new standards for Australian herpetology by attempting to use all available material, not just the specimens available in a single institution. Despite this use of large amounts of material from diverse sources to derive his distribution maps, he provided precise locality data for few specimens, and cited museum numbers only for primary type specimens he had described. Many of the species were known from only a few specimens, from widely separated localities. Distribution maps and statements derived from these initial mapping efforts have often joined these widely-spaced sites to produce broad,

almost Australia-wide distributions for many species (Kinghorn, 1929b, 1956; Worrell, 1963; Cogger, 1975; Wilson & Knowles, 1988; Gow, 1989; Hoser, 1989; Mirtschin & Davis, 1992) that have not been supported by subsequent workers using modern material (Storr, 1981; Swan, 1990; Ingram & Raven, 1991; Ingram & Covacevich, 1993; Shea, 1995; Shea & Horner, 1997).

This paper is the result of a search of early Australian museum collections and registers to attempt to identify the basis for Waite's typhlopod distribution records, particularly those that are well outside distributions as currently known, with the aim of reconciling these anomalies. In the course of this work, new data on morphological variation became available for several poorly-known species, and are presented herein.

Waite (1918b: 1) reported examining 542 specimens in the following collections: the Australian Museum, Sydney; Macleay Museum, Sydney; National Museum of Victoria, Melbourne; Queensland Museum, Brisbane; South Australian Museum, Adelaide, and Western Australian Museum, Perth. The status of pre-1918 collections in each institution is documented below, for the purposes of identifying the material available to Waite.

**1. Australian Museum (AM).** Registration of the herpetological collections in the Australian Museum began about 1877, with a specific herpetology register beginning in 1886 (Cogger, 1979; Shea & Sadlier, 1999). Waite arrived in Australia in 1892 to take up a post at the Australian Museum. He resigned from this position in March 1906 to go to the Canterbury Museum in New Zealand, and in April 1914 became Director of the South Australian Museum (Cogger, 1979; Hale, 1928; Jones, 1992, 1995; Tyler & Hutchinson, 1993). Waite's early work on typhlopids was undertaken during his tenure at the Australian Museum, and seems to be largely based on Australian Museum material (Waite, 1893). Large numbers of typhlopids were registered during the period of Waite's employment, and he actively solicited material (Waite, 1893).

Many typhlopod records in the Australian Museum registers are stamped in blue ink "identified by Waite 1918", and these stamped entries end with a number of previously unregistered typhlopids registered as a block (R6554–88) in January, 1914. However, these identifications do not include all the typhlopids examined by Waite, as there are a number of specimens not so identified which uniquely fit localities given by Waite (1918b). Only two typhlopids were registered between R6588 and the end of 1918. Neither can be unequivocally identified as examined by Waite, although one AM R6716, *R. ligatus* (Lightning Ridge) does not correspond to a map locality (but see comments below, under *ligatus*). Hence, it is assumed that R6588 marks the end of the typhlopids available to Waite.

Determination of which pre-1918 typhlopids were identified by Waite is difficult because a number of specimens were exchanged with other institutions prior to 1918, and a number of specimens were destroyed in February 1914 due to poor condition. A large collection was exchanged to the Museum of Comparative Zoology in 1914, where they were reported on by Loveridge (1934).

Some of these were registered pre-1906, and would have been available to Waite while he was at the Australian Museum. However, none of the unique localities associated with these specimens correspond to map localities from Waite (1918b), and I assume that Waite's maps are derived only from specimens examined subsequent to his return to Australia. Even with the removal of these records, there are a number of specimens that cannot be confirmed as examined by Waite, as they have imprecise locality data which would not have been mapped, or come from regions well represented in collections, where one dot on a map would suffice for a number of specimens.

**2. Macleay Museum (MM).** The Macleay Museum at the University of Sydney has had a chequered history. The basis for the collection is the private collections gathered by three members of the Macleay family, particularly William John Macleay. The "Macleayan Collection" was donated to the University of Sydney in 1890, just before W.J. Macleay's death in 1891, with the requirement that it be curated by Macleay's curator, George Masters. Following Masters' death in 1912, the collection was poorly maintained for over fifty years, and a number of specimens were damaged, destroyed or lost associated data (Stanbury & Holland, 1988; Horning, 1994). No registration of herpetological specimens was undertaken until S.J. Copland began a personal registration system of numbers tied to specimens in the 1940s (Copland, 1946). In 1965, the curator of the Macleay Museum, Ms Jenny Anderson, began a register with a new system of numbering for all specimens in the herpetological collections (Goldman *et al.*, 1969). Thus some, but not all, specimens in the collection have two numbers, a formal registration number and a Copland number. Prior to registration, data for specimens was in the form of loose labels in or on the bottles containing specimens, and these labels have generally been retained with the specimens.

Waite studied the Macleay Museum collection in 1893 (Waite, 1893) and described one species from it in the following year (Waite, 1894), during his time in Sydney. Hand-written paper labels in most typhlopod bottles give identifications with Waite's initials in pencil, indicating his examination of these specimens. A few other bottles, although lacking these initialed labels, have similar labels with numbers up to 18, and probably represent the material loaned to Waite. The few typhlopids which lack both labels either lack all data, or are identifiable as later additions to the collection.

Curiously, although several typhlopids come from localities (King Sound, Darnley I., Cape Grenville) for which Macleay reported reptile collections (Macleay, 1877, 1888), he did not mention typhlopids in these papers.

**3. Museum of Victoria (MV).** Three systems of registration have been employed for the herpetological collections at the Museum of Victoria (J. Coventry, pers. comm.). Early specimens were identified by unprefixed numbers in a system employed for the entire museum collection that probably commenced in 1854, and was used until about 1940. A second system with R-prefix, for all vertebrate specimens, began in the early part of the twentieth century,

prior to the present D-prefixed herpetological registration system, which commenced in 1933. Many of the early unprefixes and some of the R-prefixed numbers have been reregistered into the modern system. Waite did not report receiving typhlopids from the Museum of Victoria during his period in Sydney, although he did communicate with Frederick McCoy, the director, concerning typhlopids at this time (Waite, 1893). It is probable that he first received the Museum of Victoria typhloid collections for study at the South Australian Museum following his return to Australia in 1914. A list of the MV specimens sent to Waite, together with his identifications of them, is contained in correspondence from Waite to Museum of Victoria dated 14.v.1918 (Coventry, 1970). The specimens examined fall into three series: R3080–81 (two specimens), R7055–147 (90 specimens) and R7165–204 (37 specimens). Dating these specimens is difficult. A column of dates in the register appears to be dates of receipt of the specimens, based on their arrangement. Not all specimens have dates, and the dates available are not in order, but grouped by collector or donor, regardless of locality. Thus, the date 1.viii.1908 is used for the series R7172–204, all received from the Western Australian Museum, with a range of localities, some localities with a second date, between 1896 and 1898. The latest date of receipt associated with these series is 26.iii.1917, for R7067, suggesting that the specimens were registered in 1917, probably as a block just prior to sending them to Waite.

**4. Queensland Museum (QM).** A separate register for the Queensland Museum herpetological collections did not commence until 1911, prior to which a complex system of separate donor, accession, purchase, exchange and collection registers was used for the entire museum collection (Covacevich, 1971). Waite reported examining the entire typhloid collection between 1893 and 1894 (Waite, 1893, 1894), describing a new species from the material. He subsequently examined material registered post-1911, many of the registration entries in the modern system noting that the specimen was identified by Waite. Registration numbers were not consistently available for the early material, which was slowly incorporated into the modern system, some material being incorporated as recently as 1970 (Covacevich, 1971). Hence, it is not possible to fully identify the Queensland Museum material examined by Waite on the basis of registration data. However, as the material was loaned to Waite, it can be assumed that it would have been registered prior to sending it. Hence, typhlopids registered pre-1918 are likely to have been examined by Waite. The typhlopids registered pre-1918 include a large block of consecutively numbered specimens (J2935–54) from a variety of sources, registered between 29.v–2.vi.1917 and definitely including material seen by Waite on the basis of unique localities. The next typhloid entries are a block of three specimens, J3004–06, registered 4.viii.1917, two of which are annotated as examined by Waite, and the last one of which also uniquely fits a Waite record. Then follow six typhlopids registered on three occasions between 6.ix.1917 and 22.iii.1918, none of which are annotated as examined by Waite, and for which

the few localities do not correspond to Waite's maps. Hence, it is assumed that J3006 is the most recent specimen seen by Waite. It seems that not all typhlopids registered prior to this specimen were sent to Waite, as there are several unique records which do not appear in Waite's monograph. Further, only some typhloid entries, even among series, are annotated as examined by Waite. Conversely, such annotations are not made for all specimens seen by Waite, as a few unique records corresponding to Waite's monograph are not so annotated.

**5. South Australian Museum (SAM).** On Waite's return to Australia from New Zealand in 1914, he became Director of the South Australian Museum. It seems his interest in Australian typhlopids was rekindled on his return with access to an extensive new collection (Waite, 1918b: 1). His 1918 typhloid monograph was the first paper in the new "Records of the South Australian Museum", which he had initiated (Jones, 1995), and may have been hastily prepared to meet publication deadlines. Permission for the publication of the new journal was given on 18 September, 1917, and in the nine months before the publication of the first issue on 24 June 1918, he was heavily involved in planning the new publication in addition to his usual administrative work. In the final six weeks before publication, he was also planning for an expedition to New Guinea, leaving on the day of publication of the journal (Jones, 1995).

Registration of South Australian Museum herpetology collections began in 1911, with a large backlog of typhloid material registered as a block (R802–R862) on 11.i.1918, probably indicating the completion of registration of material used for his monograph. A second block of typhlopids (R914–927) was registered on 3.x.1918, after the publication of his monograph, and consists of material received in exchange or by donation from other museums, and known to have been used by Waite in his monograph, together with some "old collection" specimens that do not correspond to localities in his monograph, and were presumably located after completion of the work.

**6. Western Australian Museum (WAM).** Although the Western Australian Museum was founded in 1892, registration of herpetological collections did not begin until 1912. Waite did not report examining material from the Western Australian Museum in his early papers, and probably borrowed the typhloid collections to examine in Adelaide on his return to Australia. Early typhloid registrations in this system, up to R630, registered May 1917, are mostly annotated as seen by Waite (either "identified" or previous identification "confirmed"). The few exceptions are generally either annotated "useless", and represent specimens disposed of at the time of registration, or do not correspond to Waite's localities, and hence were probably found in the collection after the loan was sent to Waite.



### Waite's typhlopids records

For the purposes of conformity to Waite's papers, the species are listed as in their original combinations, although all Australian species are now placed in the genus *Ramphotyphlops* (Robb, 1966). In addition to the acronyms given above for Australian museum collections, the following acronyms are used: AMNH, American Museum of Natural History, New York; BMNH, Natural History Museum, London; CAS, Californian Academy of Sciences, San Francisco; MCZ, Museum of Comparative Zoology, Harvard; NHRM, Naturhistoriska Riksmuseet, Stockholm; PNM, Philippine National Museum, Manila.

Dorsal scale counts are along the dorsal median scale row, from the first scale caudal to the rostral, to the scale immediately cranial to the terminal spine.

*Typhlops affinis*: Waite (1918b) reported examining only three specimens. One of these was from north Queensland, one from Eidsvold, and one from Campbelltown. The latter two localities are mapped, together with a literature record from Lönnberg & Andersson (1913) from Mallallah in the Kimberley. Modern records indicate a distribution only from central Queensland (Ingram & Raven, 1991) south to central-north NSW (the only definite NSW records being AM R16759, Mungindi; R135419, 6.5km NE "Karalee", NE of Enngonia, and R142984, 9km E "Beulah") in semi-arid habitats.

The Mallallah record is based on NHRM 2398, here reidentified as *R. grypus*. The specimen has 647 dorsal scales, dark head and tail, a hooked snout and the nasal cleft from the second supralabial. The Campbelltown record is probably based on AM R2422, a specimen of *R. affinis* with no locality, but with the previous registration number given the locality Campbelltown.

The only Waite localities supported by modern records are Eidsvold and north Queensland. Three early specimens correspond to the former record: AM R5333, R6343a–b (all from Eidsvold, donated T.L. Bancroft). The latter two specimens are identified in pencil in the original register as "nr *wiedii*, 18 scales, nasal cleft not on snout", suggesting uncertainty about their identification, and hence R5333 is probably the basis for the Eidsvold record. Waite's north Queensland specimen is MV R7055. One additional specimen of this species, AM R2722 (no locality) is recorded as identified by Waite in the registers, while another early AM specimen, R153041 (formerly 6426) (Gayndah) may have been overlooked by Waite.

*Typhlops australis*: Waite (1918b) maps two localities in the Northern Territory, well beyond the otherwise nearly continuous distribution in southern Australia. These are probably based on two "central Australian" localities listed by Waite: Fraser Range and McMinn's Creek. However, Fraser Range is in Western Australia, this record being based on AM R6583 (Fraser Range; Elder Expedition), the specimen identified as *Typhlops* sp. by Stirling & Zeitz (1893). The identification of this specimen is confirmed as *R. australis*. The McMinn's Ck locality is based on SAM R805 (McMinn's Ck,

McDonnell Ranges, don. Illamurta Police Station), originally identified as *T. australis*, but which is now identified as *R. endoterus* (M. Hutchinson, pers. comm.).

Waite's map also has a locality for *R. australis* north of the Kalgoorlie area, well beyond recent records from Western Australia. This corresponds with a specimen, AM R3375, from Laverton (H.P. Richards). This juvenile specimen is confirmed as *R. australis*, and has 308 dorsal scales.

The third significant outlying locality on Waite's map is his only record for NSW, a dot in the vicinity of Wagga Wagga. However, a single specimen (AM R1197, Narrandera, J.A. Morris) was in the Australian Museum collection during Waite's period in Sydney, and the dot may be misplaced on the map.

Other map localities, within the known modern range (Storr, 1981; White, 1981; Swan, 1990; Coventry & Robertson, 1991), correspond to the following early records. From the Western Australian Goldfields, the three dots correspond to AM R3365, Boulder, AM R2172, SAM R172, Kalgoorlie and QM J119 (ex AM), J2951, Coolgardie, with an additional poorly localised specimen, WAM R27 (Goldfields), known to have been seen by Waite.

The five south-western Western Australian dots on Waite's map correspond to the following specimens of *R. australis*, of which the MV, SAM and WAM specimens were identified as such by Waite: AM R2372 (destroyed 1965), R2440–41, Perth; AM R2985, Harvey agricultural area, 80 mi. S Perth; MV R7181, Chidlow's Well; R7188–89, Mortlock, Perth (1898); R7191, Mandurah (1897); R7194, Perth (1898) (the latter five specimens received from WAM, presumably prior to the initiation of the modern registration system); SAM R859, Bunbury; WAM R212, Meckering; R456, Muchea and R620, Beechboro, with the Perth, Chidlow's Well, Mortlock, Mandurah and Beechboro specimens represented by a single dot (Waite, 1918b: 14). Additional specimens of *R. australis* available to Waite from this region were identified by him as *R. wiedii* (see below).

It has been possible to match specimens to most of Waite's South Australian localities, but not to all. The exceptions are among a number of dots along the coastal plain north of Adelaide, and two dots close to the Victorian border. Specimens which match mapped localities (including Adelaide suburban localities represented by a single dot; Waite, 1918b: 14) are: AM R131183 (formerly 6425), SAM R813, Pt Lincoln; MV R7063, Franklin Harbour; SAM R9, Tanunda and Murray Flats; R63, Salisbury; R281a–b, Eden Hills; R286, R439, Purnong; R299, Sleeps Hill; R393, Quorn; R411, Mulgundawa; R436, Mitcham; R478, Renmark; R480, Cleve; R627, Monarto South; R774, Wirrabara; R782, Angaston; R788, Loxton (now missing); R790, Karoonda; R806, Athelstone; R807, Orroroo; R808, Kapunda; R809, Emu Flat; R810, Lyndoch Valley; R812a–b, Stony Ck, Willowie Forest; R814, Nuccaleena; R815, Kapunda (now missing); R816, Laura; R817, Denial Bay; R818, Tea Tree Gully; R819, Edithburg (now missing); R820, Cowell; R821, Stockport; R822, Highbury; R825, Tanunda (now missing); R826, Punyelroo; R855, Taillem Bend; R856, Waterfall Gully; R857a–b, Fowlers Bay; R858, Paratoo; R860, Stonyfell; R861, Strathalbyn; R867a–b, Ooldea.



The three Victorian localities correspond to MV R7109, Beulah; R7125, Mallee; R7165, Mallee district, and R7131–36, Ouyen.

Additional unlocalised or poorly-localised specimens known to have been seen by Waite or available in collections at the time are AM R4978–80, MV R7176, R7185, R7192, R7197, R7202–03 (all ex WAM), WA; AM R6556 (exchanged to PNM in 1950), MV R7094, R7116, QM J2952, SAM R863, WAM R359, R629, no locality; AM R6557–58, R131180 (formerly 6393), R131181 (formerly 6416), R131182 (formerly 6422), SAM R724, R824, SA; R811, Murray Scrub, SA.

AM R6557–58 are very large adults with angulate snouts, labelled by Waite “*T. bicolor*, snout sharp-edged; put aside for comparison” (see also Waite, 1897a). Similarly angulate snouts are characteristic of large eastern Australian specimens, and appear to be an ontogenetic development, as they are absent in small individuals, while larger individuals have progressively more angulate snouts. In contrast, the nominotypic population of *R. australis* usually has a rounded snout at all growth stages (Storr, 1981).

*Typhlops batillus*: This species was described by Waite (1894) from a unique specimen with locality Wagga Wagga in the Macleay Museum collection. The holotype, later registered as MM R669, was transferred to the Australian Museum on permanent loan, where it is registered as R42756 (Cogger, 1979). The species was listed as distinct by Waite (1918b), Kinghorn (1929b, 1956) and Worrell (1963), none of whom reported additional material. McDowell (1974), when revising the New Guinean and Solomon Islands typhlopid fauna, examined the holotype because of a general similarity in head shape with Solomons species *R. subocularis* (Waite, 1897b), subsequently referred to the genus *Acutotyphlops* (Wallach, 1995). McDowell reported that the head was not as distinctly pointed as in Waite's (1918b) illustration, and that the holotype was female and possessed a rectal caecum. Cogger (1975 and subsequent editions) did not list the species among the Australian herpetofauna, misinterpreting McDowell's comments as suggesting that the species was not Australian (H.G. Cogger, pers. comm.). Cogger *et al.* (1983) regarded the type locality as suspect. Cogger's exclusion of the species from the Australian herpetofauna was followed by most subsequent authors (Wilson & Knowles, 1988; Swan, 1990; Weigel, 1990; Ehmann, 1992), although it was regarded as a distinct species from New South Wales by Welch (1994).

Because the holotype is female, it is not possible to definitely assign it to *Ramphotyphlops*, the genus to which all other Australian typhlopids belong, and because of the possibility that the type locality is erroneous, it is necessary to extend comparisons with other species internationally. The Macleay Museum collection contains non-Australian reptile material, including typhlopids.

I have examined the holotype of *T. batillus* and compared it to descriptions of all other typhlopid species (as listed by Hahn, 1980; Welch, 1994, with additions by Auffenberg, 1980; Rodrigues, 1991, Wallach, 1993a, 1994). In addition to the features described by Waite (1894, 1918b) and

McDowell (1974), it has 557 dorsal scales, the second supralabial overlapped by the preocular, 21 subcaudal scales, and only a single elongate postocular scale. The longitudinal scales rows are 26 anteriorly (at level of 44th dorsal), reduced to 24 by the 200th dorsal, and to 22 just anterior to the vent. The eye is prominent and has an obvious pupil. Scale organs are abundantly present on the rostral, nasal, ocular, and preocular, and fewer on the frontal, supraocular, parietal, interparietal, postocular, supralabials, infralabials and some chin shields, while obvious glands are lacking along the margins of the head shields.

The species does not agree with the diagnoses of the genera *Acutotyphlops*, *Cyclotyphlops*, *Rhinotyphlops* or *Xenotyphlops* (in den Bosch & Ineich, 1994; Wallach, 1994, 1995; Wallach & Ineich, 1996).

Among the species of *Ramphotyphlops*, with which it shares a T-III supralabial imbrication pattern (Wallach, 1993a,b), with the second supralabial overlapped by the preocular, it shares 24 midbody scales only with *R. acuticaudus*, *R. cumingii* and *R. lineatus* in Asia and the Pacific, and *R. ligatus*, *R. unguistrostris* and *R. yirrikalae* in Australia. The three non-Australian species have fewer dorsal scales (maximum 497 for *R. cumingii*; Wallach, 1994), while all three Australian species have the nasal cleft contacting the first infralabial (*vs* second). Additionally, *R. ligatus* has fewer transverse scale rows (ventral scales up to 435; Storr, 1981) and a nasal cleft that extends parallel to the rostral well onto the dorsal surface of the head (*vs* passing medially from nostril to contact rostral, barely visible from above), *R. unguistrostris* has fewer transverse scale rows (ventral scales up to 474; Storr, 1981) and an angulate snout profile, and *R. yirrikalae* has fewer dorsal scales (447–450 in the holotype and AM R12889) and a broader rostral.

Comparison with the numerous *Typhlops* species is made on a geographic basis. None of the African or European species possess the combination of a T-III supralabial imbrication, 24 midbody scales and 557 dorsal scales (Roux-Estève, 1974; Grillitsch & Grillitsch, 1993).

None of the South American species have 24 midbody scales (Peters & Orejas-Miranda, 1970; Dixon & Hendricks, 1979; Rodrigues, 1991). Although two species of Caribbean typhlopids have 24 midbody scales as a mode or occasional variant (Thomas, 1989), they also either have a posterior reduction to 22 rows of body scales well forwards of the vent and a short tail (*T. biminensis*, Thomas, 1968), or a preocular with a strong anterior projection into the nasal, the third supralabial contacting the nasal and fewer dorsal scales (*T. dominicanus* Richmond, 1966).

Among the Malagasy and Comoran typhlopids, only *T. mucronatus* has both 24 midbody scales and a distinct eye (Guibé, 1958; Roux-Estève, 1980), and this species differs from *R. batillus* in having the nasal cleft contacting the first supralabial, and the tail as wide as long (Boettger, 1881).

Among the Asian species, only *T. bothriorhynchus*, *T. depressiceps*, *T. diardi*, *T. hypogius*, *T. klemmeri*, *T. kraali*, *T. oatesi*, *T. trangensis* and *T. wilsoni* have 24 midbody scales (Wall, 1908; Taylor, 1962; McDowell, 1974; Savage, 1950; Wynn & Leviton, 1993; Wallach, 1993a, 1994). All of these except the poorly-known *T. wilsoni* differ from *R.*

*batillus* in one or more of the following characters: dorsal scales fewer than 400, a T-V supralabial imbrication pattern, and snout profile rounded (McDowell, 1974; Wallach, 1994). As originally described, *T. wilsoni* differs from *R. batillus* in having a distinct subocular scale between ocular and supralabial (Wall, 1908).

Hence, *T. batillus* is distinct from all other described typhlopoid species. Although it can not unequivocally be placed in *Ramphotyphlops*, it is most similar to that genus in the supralabial imbrication pattern. The only reported locality, Wagga Wagga, is not inconsistent with the Macleay collection history. William John Macleay was a grazier in the Riverina, owning “Kerarbury” Station, and a vineyard at Wagga Wagga. Further, he was known to have made at least one collecting trip to Wagga Wagga with his collector and curator, George Masters, in January 1874 (Fletcher, 1893; Stanbury & Holland, 1988; Horning, 1994). In the absence of any evidence to the contrary, *R. batillus* should be reinstated as a member of the Australian herpetofauna, known only from a single locality. The lack of any recent records from this district, despite herpetological collections over a number of years (Annable, 1995) is disturbing, and the conservation status of this species should be urgently evaluated.

*Typhlops bituberculatus*: Waite’s (1918b) map differs from modern distribution maps for the species (White, 1981; Storr, 1981; Swan, 1990; Ingram & Raven, 1991) in the inclusion of records from Bundaberg, Qld, Barrow Creek, NT, eastern NSW (a dot placed about Katoomba), Fortescue River, WA, central WA (a dot placed about Lawler), and south-western WA (five dots).

The Bundaberg record is probably based on MM R444 (Bundaberg, no other data), which is confirmed as *R. bituberculatus*. The specimen is a juvenile in very poor condition. As this species is not otherwise known from eastern Queensland, with the nearest records in south-central Qld (Ingram & Raven, 1991), the record is regarded as suspect.

The Barrow Creek record is presumably based on SAM R830 (Barrows Creek, no collector, old collection), the identity of which is confirmed as *R. bituberculatus*. This specimen has about 490 dorsal scales (M. Hutchinson, pers. comm.). There are no other confirmed records of this species from the same latitude or further north, and the record should be treated as suspect.

Four of the five dots in south-western WA correspond closely to early typhlopoid records subsequently reidentified (Storr, 1981) as *R. waitii*, a superficially similar species sharing a trilobed snout, 20 midbody scales and a nasal cleft proceeding from the second supralabial and which Waite was unable to identify from Boulenger’s (1895) description: MV R7199, Bullsbrook (ex WAM); MV R7172, R7193, Cranbrook (ex WAM); WAM R403, Carnamah; WAM R421, Williams. The remaining locality, from the coast, may be based on AM R2429, Perth (presented by W.D. Campbell), here confirmed as *R. bituberculatus* (501 dorsal scales, 485 ventral scales, rostral not with a hooked margin), MV R7183–84, R7196, Perth, and R7190, Mortlock, Perth. Of the latter four specimens, all ex WAM and identified by Waite as *T. bituberculatus* (J. Coventry, pers. comm.), R7196 is now identified as *R. waitii*, while the remaining three

specimens are confirmed as *R. bituberculatus* (G. Storr, *in litt.* to J. Coventry, pers. comm.). The locality for R2429 presumably represents a shipping point or is in error, as other reptile collections presented by Campbell either have the locality Perth but include inland species, or have the locality Boulder. The central WA record is probably based on AM R3355 (now AMNH 20942), Lawler (pre: G. Shipton). The Fortescue River record is probably based on SAM R220 (Fortescue River, W.D. Dodd), although that specimen is apparently lost. The record is within the range of *R. waitii* (Storr, 1981), and is presumed to be based on that species. The remaining WA locality, within the known modern range of the species (Storr, 1981), is probably based on AM R153051 (formerly part of R1693), Coolgardie, together with two poorly localised specimens, WAM R26, R448 (“Goldfields”).

The basis for the eastern NSW locality remains difficult to determine. There are two records of *R. bituberculatus* from eastern NSW, although neither fit the mapped locality precisely. AM R64, Callan Park (a Sydney locality), was originally identified as *Pygopus lepidopodus*, but subsequently reidentified as *R. bituberculatus* in Waite’s handwriting. This record is rejected, due to the lack of confirmatory records from east of the Great Dividing Range and the potential for association of the wrong specimen with the tag suggested by the change in identification. The second record is AM R131179 (formerly A2475), from Mr Walter Blaxland’s Station, the identification being initialled by Waite. The collection of which this specimen is part is annotated in the original register with what appears to read “Cullingral, Merriwa”.

Identifiable specimens corresponding to most of Waite’s other NSW dots are: AM R1693, Dubbo; R2723, Broken Hill; R1176, Menindee; R3551, Narrandera; R3640, Lake Cargelligo; R4259 (now AMNH 20948), Shuttleton; R4403, N Broken Hill; R5109–10, Corella, nr Brewarrina; MM R670, Wilcannia; R671, Coonabarabran; SAM R831a–h, Silverton; MV R7071, Jerilderie and MV R7086, Deniliquin. One specimen with a precise locality, AM R1448, Tocumwal, does not appear on his 1918 map.

The ten Victorian localities, all within the modern range, correspond in part to the following specimens: MV R7060, “Bathry” Stn, Terricks; R7065, R7126–33, R7137, Ouyen; R7076, Beulah; R7078, Mallee; R7085, Gunbower; R7092, Myall, via Koondrook; R7100, near Gerang; R7106, Nhill; R7138–43, Woomelang, although one specimen seen by Waite, MV R7083, Goulburn Valley, is not mapped, I have been unable to identify the locality for another (R7064, Cashel), and the southernmost locality cannot be related to a specimen.

South Australian records corresponding to Waite’s map localities are: SAM R541, R832–34 (R834 now missing), Murray Bridge; R547, Yorke Peninsula; R617, Kadina; R630 (now missing), Streaky Bay; R646 (now missing), Quorn; R656, Modbury; R667, 408 Mile, East-West Line; R813, Pt Lincoln; R828, Kopperamanna, Coopers Ck; R829 (now missing), Semaphore; R834a–b, Purnong; R835, Ardrossan; R836 (now missing), Denial Bay; R837, Roseworthy; R839a–b, Leigh Creek; R840, Oodlawirra; R841, Kadina; R842, Yundnamutana; R843a–b (now missing), Orroroo; R844, Kapunda; R845, Pt Pirie; R846a–



e, between Ooldea and Talarinna (only a–c now present); R847, Kilalpaninna; R887 (now missing), Reedbeds. One SA specimen available to Waite, but not mapped is SAM R540, Pernatty Lagoon. Waite localities for which specimens are not identifiable include several peripheral localities in a cluster about Adelaide and the Murray region to the east, and the two north-easternmost localities in the state, one of which probably corresponds to Strzelecki Ck (Waite, 1917).

Additional to these are the following poorly-localised specimens of the same vintage: AM 6418 (not found), R1917, R6559, R131171–73 (formerly 5180), R131174 (formerly 6406), R131175–78 (formerly 6417, 6419–20, 6423), MV 7099, SAM R848 (36 specimens, destroyed 1965), no locality; AM R1451 (7 specimens), Darling River floods; R5027, MM R672–73, QM J1914 (formerly AM R1567), NSW; AM R6585, interior of NSW?; R131175–78 (previously 6417, 6419–20, 6423), SAM R217, R301, SA; MV R7103, Vic; R7204, WA; SAM R838a–e, Murray Scrub, SA.

One specimen potentially available to Waite does not correspond to a map locality: QM J1915, Roma, Qld. The registration entry for this specimen is annotated “on exhibit, removed 1954”, and it was presumably not sent to Waite.

*Typhlops broomi*: Waite (1918b) reported examining five specimens, and gave the localities Cairns, Norseman, Broome and Mallee, Vic., the latter three well outside the known modern range (Ingram & Covacevich, 1993; Shea, 1995). The Cairns locality is probably based on SAM R851, Cairns (A.M. Lea, old collection, registered 11.i.1918). The Broome record is based on a specimen of *R. diversus*, SAM R925 (previously MV R7182, itself received from WAM) from Rowe, Broome, initially identified as *R. broomi*. The Norseman record is based on MV R7066, identified by Waite as *R. broomi*, but reidentified as *R. australis* (Storr, 1981). The fourth locality, “Mallee, Vic.” is based on MV R7170 (Mallee district, C. Frost per J. Frost), data which appears on a number of MV specimens of dubious provenance, including other typhlopids. The record was rejected by Robertson *et al.* (1989) and Coventry & Robertson (1991). The remaining specimen available to Waite (AM R2034, north Queensland) was identified by Shea (1995). Two additional specimens, QM J2953–54 (Stannary Hills, nr Herberton) were potentially available on the basis of registration date, but were either not seen or overlooked by Waite.

*Typhlops diversus*: Waite (1918b) stated that he had examined four specimens, but indicated five localities on his map. Two of these correspond to previous literature records: the type of *Typhlops ammodytes* from the Monte Bello Islands, and two specimens from Noonkambah in the Kimberley reported by Lönnberg & Andersson (1913), the latter based on NHRM 2396–97, which I confirm as *R. diversus*. The type locality, Morven, Qld (given as Mowen by Waite, 1894, but subsequently corrected by Waite, 1918), corresponds to the only Queensland locality mapped, while the remaining two map localities are in the Northern Territory, one in the Darwin area and the other about Tennant

Creek. The latter two records are probably based on SAM R862, (Tennant Creek, J.F. Field) and one of QM J2590–91 (Darwin, G.F. Hill). J2590–91 are misidentified *R. towelli* (K. Aplin, pers. comm.). The fourth specimen, not corresponding to a map locality, is MV R7112 (no data).

*Typhlops endoterus*: Waite (1918b) described this new species from three specimens from Hermannsburg, but gave the number of only the holotype (SAM R88). The two paratypes (SAM R87, R89) were identified by Houston (1976).

*Typhlops grypus*: Waite (1918b), when describing the species, stated that he had four specimens, the type in the Museum of Victoria, the others in the Queensland Museum and South Australian Museum. Of the four, one was from Marble Bar, one was from “Gregory Downs”, and two lacked localities. The holotype (MV R7102, now D12351) lacks locality data. A second MV specimen, R7200 (now D12358), from Marble Bar, was identified as a paratype by Coventry (1970), who noted that correspondence from Waite proved that the specimen was available to him at the time of description. Hence, one of the other two specimens, which are paratypes, must be from “Gregory Downs”, the other lacking locality data, and they must be in the Queensland and South Australian Museums. The only specimen in the latter collection available at the time of Waite's revision is SAM R849, no locality apart from the enigmatic comment “in stomach of spec at Semaphore”, and presented by Dr Wylde. There are four early QM typhlopids with locality “Gregory Downs”: J2944–47. Of these J2945 was destroyed in 1953 without any identification. The remaining three are all *R. grypus*. Only J2947 is annotated as identified by Waite and must be the remaining paratype. Presumably Waite was only sent one of the series.

*Typhlops guentheri*: Waite's map (1918b) has four localities. Three of these correspond to literature records (Daly River; Boulenger, 1895) or early specimen records (AM A4872 [now R150870], QM J2266, Pt Darwin; MV R7073, Oenpelli, East Alligator River) corresponding to the known distribution (Shea & Horner, 1997). The remaining locality is identified as Marble Bar in Waite's description. The record corresponds to WAM R535 (Marble Bar), first registration identification *T. nigricauda*, identified by Waite as *T. guentheri*. This specimen was subsequently reidentified as *R. affinis* by G. Storr (annotation in register), but was not listed by Storr (1981). It was later reidentified as probably *R. grypus* by L. Smith in 1990 but cannot now be found to verify the identification (L. Smith, pers. comm.). The first identification of this species as *T. nigricauda* suggests that the tail was black, and the later identification as *R. affinis* suggests that the snout was at least angulate. These two features suggest that the record is a misidentified *R. grypus*. Four additional specimens (AM R2292 (ex SAM), MV R7111, SAM R802a–b, all no data) are known to have been identified by Waite as *R. guentheri*. Of Waite's *guentheri* records, AM R2292, R150870 and SAM R802b have been subsequently reidentified (Shea & Horner, 1997) as *R. nema*.

*Typhlops kenti*: Waite (1918b) examined four specimens of this species, since synonymised with *R. affinis* (McDowell, 1974): from King's Sound, Broome, "Yanyerreddy" Station (near Ashburton River) and "Western Australia". All are well beyond the known distribution of *R. affinis*. Waite stated that "in three specimens the tail is black, in one other the head is also black". These black markings indicate that Waite's specimens were *R. grypus*, (Parker, 1931, as *T. nigroterminatus*). Two of his records are based on MV R7187 (ex WAM), Rowe, Broome and MM R683, King Sound, both specimens of *R. grypus*. Possibly the "Yanyerreddy" Station record is based on SAM R804, a specimen of *R. grypus* (original identification *T. kenti*) from between the Ashburton and Gascoign [sic] Rivers, 1895, P. St. Barbe-Ayliffe. The remaining poorly localised specimen corresponds to MV R7179 (WA). One additional specimen, WAM R145 (Derby) was present in the WAM collection at the time, but is not identified as examined by Waite, and does not correspond to his listed localities.

*Typhlops labialis*: This species was described by Waite (1918b) from a unique specimen (WAM R630) with locality stated as Western Australia. Although it appears as a valid species in several subsequent publications (Kingham, 1929b, 1956; Glauert, 1950; Worrell, 1963), the name was synonymised with the widespread Asian species *Typhlops diardi* by McDowell (1974). The Western Australian locality is erroneous, as the holotype lacks any associated data (McDowell, 1974).

*Typhlops ligatus*: One specimen mapped from north-west Victoria is well beyond the known range in northern NSW, Qld, NT and the Kimberley (Wells, 1979; Storr, 1981; Swan, 1990; Ingram & Raven, 1991). The source for this record is presumably SAM R921 (ex MV R7167) and MV R7168 (Mallee, Victoria), the latter noted by Rawlinson (1966). A locality in western NSW mapped by Waite, west of localities mapped by Swan (1990) in NSW, is probably based on MM R446 (2 specimens), "Wonaminta", nr Wilcannia, here confirmed as *R. ligatus*. The specimens are juveniles in poor condition, but dorsal scale counts are approximately 317–323 for the two. The Victorian records are from an imprecise locality associated with several other species not subsequently confirmed from the area (*R. broomi*, *R. nigrescens*, *R. pinguis*, *R. proximus*, *R. unguistrois*), and are treated as erroneous. The western New South Wales record, however, although similarly not confirmed by recent material, is from a poorly collected area, and should continue to be treated as valid until evidence to the contrary becomes available.

Six of the remaining seven localities mapped by Waite (1918b), in northern NSW and eastern Qld, correspond to AM R153040 (formerly A10637), Coomooboolaroo, Qld (Waite, 1893); R3970, Brewarrina, NSW; QM J1212, Wycombe, Surat, Qld; J2828, "Lochnagar", Central Railway Line, via Barcaldine, Qld; J2940, Rockhampton, Qld; SAM R197, Buff, Rockhampton, Qld; R850, Niall, "Delta" Stn, Alice, Qld, and the type locality (Mackay), all within the currently known distribution of the species. One other mapped locality, north-west of Brewarrina, cannot be

associated with specimens, unless it is a misplaced Lightning Ridge (AM R6716). To the above-listed specimens can be added the holotype of *Typhlops curtus* (AM R1132), examined by Waite (1893). The type locality (Walsh River) was presumably considered too imprecise to map (Waite, 1918b: 14). Also known to have been seen is MV R7068 (Qld). Three other specimens with imprecise localities were available in collections examined by Waite: AM R153038–39 (formerly 5179, 6405; no locality); QM J2048 (destroyed 1964; probably Qld); J2742 (central Qld); J2941 (destroyed 1965, no locality), although it cannot be confirmed that they were seen by Waite.

Four specimens of appropriate vintage with localities in south-eastern Qld (QM J623, Brisbane, Qld; J624, Dalby, Qld; J2939, Toowong, Brisbane, Qld; SAM R50, Lowood, Qld) do not correspond to localities on Waite's map. The number of localities and variety of sources of these specimens suggest that Waite's map was incomplete in this instance, rather than that he did not see this material.

*Typhlops pinguis*: Waite (1897a) described this species from a single specimen from an unidentified locality in South Australia, the holotype being identified by Waite (1918b) as SAM R803 (registered in 1918; Houston, 1976). Waite (1918b) identified a second specimen from Mallee, Victoria, and mapped four localities in far south-western Australia. The species is now known only from the latter region (Storr, 1981). The Mallee specimen is SAM R922 (previously MV R7166, Mallee, Victoria), while six other early specimens fit three of the four map localities in Western Australia: MV R7173 (ex WAM), Wokalup; SAM R924 (ex WAM R426), Capel; SAM R923 (ex MV R7174, itself ex WAM), WAM R473, Katanning; WAM R590, Kojonup and WAM R624, Wickepin (assuming Wokalup and Capel are represented by a single dot). All but the last specimen were examined and their identity confirmed by Storr (1981). Four other poorly localised specimens were seen by Waite: MV R7175, R7180, R7195, R7201 (all from WA, ex WAM), and two other specimens with the same locality (AM R4976–77, not found) may have been seen by him.

*Typhlops polygrammicus*: Waite's (1918b) concept of *T. polygrammicus* is now known as *R. nigrescens*, following Smith (1927). Waite's distribution map for this species closely approximates the distribution based on modern records (Swan, 1990; Coventry & Robertson, 1991; Ingram & Raven, 1991) except for the two westernmost localities in Victoria and a record from extreme south-east New South Wales. The latter is probably based on SAM R917 (ex AM R1790), Twofold Bay and AM R2295–96 (not found), Bega (R. Etheridge).

Specimens corresponding to localities in the main body of the species' distribution in NSW include AM R905, West Bargo; R1093, R1602, R2027 (not found), R5183, Walcha (R1093 sent to R.M. Bousek in 1925; R1602 now CAS 77814–15); R1521 (not found), Warri, via Braidwood; R1574, R1734 (destroyed 1965), Kempsey; R2412–14, Murwillumbah; R2720, Armidale (now CAS 77816); R4189, Mudgee district; R5975–76, Broughton I.; R6567–70, Tharwa (collected by Waite; R6567 now AMNH 20946;



R6568 not found); R131153, Port Macquarie (formerly 6394); R131170, Mittagong (formerly B9905), and a number of specimens from Sydney suburbs, which are represented by a single dot (Waite, 1918b: 14). It is not possible to unequivocally determine which of the many AM specimens from Sydney listed in the early registers were examined by Waite. However, at least the following Sydney specimens are annotated "examined by Waite 1918": R5, Woolahra; R8, Hunters Hill; R108, Homebush; R398, Randwick; R780, Auburn; R1405, Waverley; R1442, Marrickville; R6554–55, Penrith, while the following additional Sydney region specimens were registered pre-1918 and, in the absence of contrary data, presumably available post-1914 to have been sent to Waite: A8920 (now CAS 77812), R131149 (formerly 5175), R131154–55 (formerly 6398–99), R1311161–62 (formerly A238, A522), Sydney; R625, South Creek, St Mary's; R673 (not found), Riverstone; R674 (not found), Bulli; R1189 (not found), Granville; R1246 (not found), Campbelltown; R1610 (not found), Cabramatta; R1664, N Sydney; R1927, Waverley; R2173 (not found), nr Liverpool; R2301 (destroyed 1965), R3787 (destroyed 1924), Penrith; R2376, Balmain; R2518, Mosman; R2532 (now AMNH 20943), South Head; R3208–10 (only R3209 found), Fairfield; R3655 (now AMNH 20944), Coogee; R3659 (now CAS 77813), Alexandria; R4573, Randwick; R4599, Mosman Bay; R4622, Freshwater; R4816, Bellevue Hill; R5393, Camden; R5971, Lakemba; R131164 (formerly A2813), Smithfield; R131165 (formerly A6386), Woolahra; R131167 (formerly A8924), Kogarah; R131169 (formerly B3704), Field of Mars. Added to these is MM R677, Sydney ("examined ERW").

Nine additional early specimens from NSW which do not correspond to a map dot (AM R911, R1452, MM R678, Richmond River; MV R7096, Clarence River; R7119–23, Macleay River) were presumably excluded because of the imprecise localities (the first is identified in the registers as the basis for the figure of the tail of *T. ruppelli* in Waite, 1893). Conversely, two specimens (R1460, Bendenine; R2719, Salisbury Plains) are annotated as examined by Waite, but do not correspond to map localities, and there are three mapped localities in NSW within the modern range for which corresponding specimens cannot be identified.

Victorian specimens corresponding to Waite's map dots are: MV R3081, Kewell; R7057, Tallangatta; R7059, Mallee; R7074, Alexandra; R7079, R7113, Bright; R7087, Goulburn, and R7090, Tooboorac, although no specimen can be found to correspond with one of the western Victorian localities.

The single Queensland dot, about Brisbane, corresponds to QM J2874, J2884, Tamborine Mtn; J2875, St Helena I., and J2942, Brisbane, of which the first is definitely recorded as examined by Waite.

Other poorly localised specimen known to have been seen by Waite, or available pre-1917 and probably post-1914 are: AM R7 (not found), R90, R126 (not found), R955, R1068 (now SAM R919), R1092 (not found), R1121, R2547–48, R2550–53, R2572, R2577 (not found), R2721, R2728, R3859 (now SAM R918), R6021, R6023–25, R6566, R6571–80 (R6572, R6580 not found), R131150–51 (formerly 5176–77), R131156–58 (formerly 6400, 6402,

6404), MV R7061, R7110, no locality; AM R1229 (not found), R1235, NSW?; R131159–60 (formerly 6407–08), R131163 (formerly A1872), MM R674–76, MV R7081, NSW; R7091, Vic; QM J1931–33 (destroyed or not found 1965), Qld; J1935–36 (destroyed or not found 1965), Qld or NSW; J2049 (destroyed 1964), probably Qld.

One specimen present in early collections, but not mapped or mentioned by Waite, presumably rejected without comment because of its distance from other records if indeed it was seen, is AM R131168 (formerly A10182), Nicol [=Nickol] Bay, WA.

*Typhlops proximus*: This species was described by Waite (1893), who nominated AM 6411 (now R131704), from NSW, as holotype, but noted that he had several specimens available to him. Specimens of *R. proximus* in the Australian Museum registered prior to 1893, and hence available to Waite and potentially paratypes are: 5181 (not found), R95 (now SAM R915, skeletonised), R1115, (exchanged with R.M. Bousek in 1923); R145401 (formerly 5171), R145404 (formerly 6403), R145407 (formerly B2309), no locality; 6415 (exchanged to Baylor University 1905), R145403 (formerly AM 6397), R145405–06 (formerly 6412, 6415), NSW; R615, Richmond; R1028 (not found), Wallinbillan [=Wallanbillan], and R145402 (formerly 6396), West Maitland.

Waite (1918b) maps a relatively continuous distribution in south-eastern Australia, corresponding to the known modern distribution (Swan, 1990; Coventry & Robertson, 1991; Ingram & Raven, 1991), but with three outlying localities, one in north Queensland, one in western NSW and one in north-western Victoria. The north Queensland locality on the map corresponds to the text reference to a distribution south of 17°05'S, and is probably based on the specimen from Malanda (17°22'S) reported by Lönnberg & Andersson (1915). This record is based on NHRM 22456, the identity of which is confirmed as *R. proximus*. Two other specimens are known from the same region (McDowell, 1974: AMNH 27263, Ravenshoe district; AM R148795, 8.2km ESE Ravenshoe, Herberton district), validating this record, although a literature record from further north (Ingram & Raven, 1991, based on J38221, "Silver Plains") is based on a misidentified *R. unguistrostris* (P. Couper, pers. comm.). The Atherton Tableland population appears to be isolated from the main distribution, and may have greater dorsal scale counts (390 for R148795, 392 for NHRM 22456 vs 326–378,  $\bar{x}$  = 349.9, SD = 13.16, n = 62; latter based on AM R1497, R1570, R1845, R2343, R2722, R2724, R2727, R3440, R5764, R6560, R6562, R6564, R7221, R7982, R8440, R8982, R10182, R10437, R10776, R10786, R11498, R11693, R12255, R12307, R12526, R13115, R13448, R13661, R13779, R13830, R13835, R14821, R14946, R15218, R15868, R15936, R17915–16, R18289, R18886, R27304–05, R27313, R30331, R49083, R64294, R66665, R86811, R92391–93, R95270, R95458, R111876, R114565, R118650, R122967, R123430, R128510, R132486, R144603, R144776).

The basis for Waite's western NSW locality, a dot in the vicinity of Tilpa, is not known, as it does not correspond to any identifiable specimen in early collections, unless the

dot represents the Darling River generally (AM R6561, now AMNH 20947, Darling River). The north-western Victorian record is probably based on SAM R922 (Mallee area, Vic), and is probably erroneous, as with other records from this locality.

Other specimens that were available to Waite, and correspond to localities on his map, are, in addition to the localities cited above: AM R1497, R1845, SAM R914 (ex AM R1844), Moree, NSW; AM R1570, R2343, Murrumburrah, NSW; R3440, Manilla, NSW; R5764, Tamworth, NSW; MV R3080, Charlton, Vic; R7067, Macorna, Vic; R7070, Murchison, Vic; R7076, Beulah, Vic; R7082, R7108, R7115, Wangaratta, Vic; R7105, 50mi W Toowoomba, Qld; QM J237 (destroyed), Wondai, Qld; J239, Clayfield, Brisbane, Qld; J362, Woodford, Qld; J1904, Bundaberg, Qld; J2935, Dalby, Qld; J2936, Goodna, Brisbane, Qld; J2937, Glasshouse Mtns, Qld; SAM R200, Mungar Junction, Qld; SAM R916 (ex AM R5690), Budden, Rylstone, NSW. Also seen by Waite (register annotations) are AM R2724, R6560, R6562, R6564, QM J3004, no locality. Three map localities, in the vicinity of Glen Innes, NSW, the north-easternmost NSW locality and the easternmost Victorian locality, cannot be associated with specimens.

Localities for two of the potential paratypes (Richmond and Wallanbilla), together with three MV specimens known to have been examined by Waite (R7077, Moora South, Vic; R7094, Kewell, Vic; R7101, "Nauranny", Murrumbidgee, NSW) do not appear on Waite's map. Wallanbilla, Moora South and "Nauranny" may not have been identifiable by Waite, while he may have confused Richmond with Richmond River, possibly corresponding with the otherwise unreconcilable dot in north-eastern NSW on his map.

Other poorly-localised specimens that may have been seen by Waite are: AM R2727; QM J2938 (destroyed 1965), no locality, and J1934 (destroyed 1965), Qld.

*Typhlops torresianus*: Waite's concept of *torresianus* equates to the species *R. polygrammicus* of most subsequent authors. Queensland Museum records (Ingram & Raven, 1991) and Australian Museum material of this species are solely from north-eastern Queensland, as are the majority of Waite's records. Waite maps one locality in south-eastern Qld. The basis for this record is QM J3006 (Brisbane), original identification *T. torresianus*, current identification *R. polygrammicus*. This species is very similar to *R. nigrescens* (Waite's *T. polygrammicus*), differing primarily in the origin of the nasal cleft (from the first supralabial in *nigrescens*, from the second in *polygrammicus*), and it is possible that the specimen is an aberrant *R. nigrescens*.

Other specimens of *R. polygrammicus* potentially available to Waite or known to have been examined by him, and corresponding to his map localities are: AM R1083, Bellenden Ker Range; R1926 (not found), Ripple Creek, Herbert River; R4691, Dunk I.; MM R685, Cape Grenville (now in very poor condition); MV R7117, Kuranda; QM J2273, Gordonvale and SAM R927 (ex MV R7095), Qld, assuming that R1083, R1926, R7117 and J2273 are represented by a single dot. The remaining mapped locality

is presumably Murray Island, type locality of *T. torresianus*.

Storr (1981: 256) is the only modern author to maintain usage of *R. torresianus* as distinct from *R. polygrammicus* from Timor, and justified his usage by claiming *R. torresianus* has fewer longitudinal scale rows (ventrals "c.350" vs 421–450). Among 12 specimens from north-eastern Australia (AM R1083, R4691, R9614, R10828, R15137, R57282, R57826, R65225, R82599, R98337, R107055, R127404), I find 370–422 dorsal scales, with higher counts predominating in the Cairns region, and lower counts in the drier country on western Cape York. These data suggest that the difference between the two forms is less than previously stated, and geographically variable. Hence, in the absence of a more rigorous study of variation throughout the range, I prefer to treat the two as conspecific.

*Typhlops unguirostris*: Waite had very few records for this species, providing four localities on his map, and noting that he had examined specimens from the type locality (Rockhampton), Darwin, Lyndoch Valley, SA and Mallee, Victoria. The Darwin locality corresponds to the map, and is probably based on AM R4582, Port Darwin. There are two mapped localities in Queensland, one corresponding to Rockhampton (MV R7058), the other to Port Bowen (= Port Clinton), type locality for the synonym *Typhlops curvirostris*. These three localities are within the modern known range of the species in tropical Australia (Storr, 1981; Ingram & Raven, 1991). However, the other two localities are well beyond this distribution. The Lyndoch Valley locality does not appear on Waite's map. The record is undoubtedly based on AM R6581–82 (Lyndoch Valley, SA, Dr Richters, "old collection"). The Mallee, Victoria locality is presumably based on MV R7080 (Rawlinson, 1966). The specimens for both records are identifiable as typical *R. unguirostris* (24 midbody scales, nasal cleft from first supralabial, angulate and strongly-projecting snout, dorsal scales 502, 477, 515 respectively), but are probably incorrectly localised.

One additional specimen, present in the Australian Museum collection from 1894, does not appear to have been used by Waite: AM R1568, Cambridge Gulf (ex QM), unless it was the basis for one of the otherwise unidentifiable *R. wiedii* records from the Kimberley. This specimen is presumably that cited by de Vis (1889). Another specimen, QM J3005, lacking locality data and destroyed in 1965, may also have been available to Waite.

*Typhlops wiedii*: The map provided by Waite (1918b) indicates a much more extensive distribution than that demonstrated by recent studies (Ingram & Raven, 1991; Shea, 1995). Beyond recent limits are two localities in the Kimberley (one about Wyndham, the other about "Theda"), one in Torres Strait, one near the tip of Cape York, one in the vicinity of Cooktown, one about Bowen, four in the south-west of WA about Perth, and one in the Western Australian goldfields.

The Cape York and Torres Strait records are probably based on *R. leucoproctus* (Boulenger, 1893). Waite (1894) had evidently regarded this as a distinct species, but he later listed it as a synonym of *R. wiedii* (Waite, 1918b). The



species was subsequently resurrected by McDowell (1974). Although the two species are superficially similar, they are allopatrically distributed, and are readily differentiated on colour (dark both dorsally and ventrally in *leucoproctus*, pale both dorsally and ventrally in *wiedii*), and have significantly different numbers of dorsal scales (*leucoproctus* 377–394,  $\bar{x}$  = 383.8, SD = 6.30, n = 8, based on AM R4537, R7956, R42661, R48541, R55678, R58961, R59060, R97853; *wiedii* 381–439,  $\bar{x}$  = 417.8, SD = 17.88, n = 10, based on AM R1846, R2001, R2729, R4122, R4544, R5908, R6344, R6563, R6565, R6584; Mann-Whitney U test, U = 75, p = 0.002). Two specimens of *R. leucoproctus* available to Waite, AM R4537, Somerset and MM R679, Darnley I, fit Waite's dots. Another specimen, MM R684, Darnley I., may have been seen by Waite, although there is no record of this with the specimen.

The Cooktown locality is presumably based on MCZ 6487 (Cooktown), identified by Garman (1901) as *R. wiedii*. This specimen was subsequently reidentified (Loveridge, 1934) as *R. affinis*, and by McDowell (1974) as *R. broomi*.

The other odd eastern Australian record, about Bowen, is presumably based on MM R442, Pt Denison (no collector recorded, but probably either George Masters, who collected at this locality for both the Macleay Museum and Australian Museum in 1861/62, or Edward Dämel, who collected at this locality in 1865–66; Fletcher, 1893; Stanbury & Holland, 1988; Tilbrook, 1992). There appears to be no reason to doubt the accuracy of the locality data for this specimen.

The south-west Australian localities are based on misidentified *R. australis*, which share with *R. wiedii* 20 midbody scales and a nasal cleft from the second supralabial and not dividing the nostril. Specimens from south-west WA registered as identified by Waite as *T. wiedii* are: WAM R410, North Jandakot (two of seven specimens originally under this number now SAM R926a–b); R457, Muchea; R507, Mundaring. These records correspond to three of four dots in this area. R457 was not examined by Storr (1981) and is apparently lost. The remaining dot, placed about Perth, is probably based on one or more of the several *R. australis* records from Perth (see above). One additional unlocalised WA specimen of *R. australis* (MV R7198) also bears the Waite identification *T. wiedii*.

The Goldfields record, to the south of Kalgoorlie, and north of Norseman (based on Waite's maps for *australis* and *broomi*) is based on WAM R318, Widgiemooltha, likewise a specimen of *R. australis* (Storr, 1981).

One of the Kimberley records is probably based on WAM R485, Forest River Mission (J.A. Dobson), identified by Waite in the register as *T. wiedii*. This specimen was not examined by Storr (1981), and is apparently lost. However, it is worth noting that two recently described Kimberley species, *R. kimberleyensis* and *R. troglodytes*, share with *R. wiedii* 22 midbody scales and a nasal cleft contacting the second supralabial (Storr, 1981). The source for the other Kimberley record is uncertain, unless it is based on a specimen of *R. unguistrostris* (AM R1568) not otherwise mapped (see above). If this is the case, the error must be considered typographical, as it is not conceivable that Waite would have confused the two very different species.

Waite's other mapped localities for *R. wiedii*, within the modern distribution, are at least partly based on the following specimens: AM R782 (now AMNH 20950), R6586, Yandebah, NSW; R1441, R3339 (not found), Dubbo, NSW; R1846, Moree, NSW; R2001, Quirindi, NSW; R4122, Clarence River, NSW; R4544, Boggabri, NSW; R5908, R6344, QM J2197–98, Eidsvold, Qld; MV R7097, Grafton, NSW; MV R7107, Pine River, Qld; QM J171, J2087, J2949, Brisbane, Qld; J890–91, Enoggera, Brisbane, Qld; J1235 (destroyed 1964), Booval, Ipswich, Qld; J2130–32, Corinda, Brisbane, Qld; J2432–33, 17 Mile Rocks, Brisbane, Qld, and J2948, Breakfast Ck, Hamilton, Qld, assuming the latter seven localities and the type locality (Brisbane) are represented by a single dot.

Other specimens that were or may have been seen by Waite, but are not mapped, are AM R1453 (currently 12 specimens, but some destroyed 1914), Darling River floods, NSW; R1596, Qld; R2729, R6563, R6565, R6584, R6587–88, MV R7144–46, QM J2445 (destroyed 1953), no locality; AM R3600, Koorawatha, NSW (registration entry notes "identified by Waite 1918"); MM R680–81 (5 specimens), Tamworth, NSW; QM J2045–47, J2059–60 (all five destroyed 1964), probably Qld; J2115, Oakey, Qld; J2730–31 (latter specimen exchanged to PNM), Pittsworth, Pampas, Qld; J2920–2921, Bowenville district, Qld. The lack of a dot in the Darling Downs on Waite's map, despite records from the latter three localities, probably represents an error on Waite's part.

Non-Australian species. Although Waite primarily worked on the Australian typhlopids fauna, he described two non-Australian species (*Typhlops subocularis* Waite, 1897b, and *Typhlops infralabialis* Waite, 1918a, both now in *Acutotyphlops*; Wallach, 1995) and reported typhlopids from Fiji (Waite, 1898). The holotypes of both new species were re-described by Wallach (1995) who, following Cogger (1979), reported that the paratype of the former species was missing. I also have been unable to locate AM R2203, identified as the paratype by register entry. However, R2169 (no locality, E. Sutton), a specimen of the same species, accurately fits the measurements provided by Waite (1897b) for the paratype and may be the missing specimen with the wrong tag attached.

Wallach (1996) could not determine the basis for Waite's Fijian typhlopids record. Register entries for AM 6428–30 state "*Typhlops* nov. sp. Wai Obi, Vanua Pi, Fiji, Mr J. Johnston, Fiji". Additionally "(Naota)" is entered against 6430. These data correspond to those presented by Waite (1898). Unfortunately, 6428 is further annotated as destroyed 1914, and the other two specimens cannot be found, and may have shared the same fate.

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<i>curvirostris</i> , <i>Typhlops</i> .....	52	<i>Ramphotyphlops</i> .....	46, 47, 48
<i>Cyclotyphlops</i> .....	47	<i>Rhinotyphlops</i> .....	47
<i>depressiceps</i> , <i>Typhlops</i> .....	47	<i>ruppelli</i> , <i>Typhlops</i> .....	51
<i>diardi</i> , <i>Typhlops</i> .....	47, 50	<i>subocularis</i> , <i>Ramphotyphlops</i> .....	47
<i>diversus</i> , <i>Ramphotyphlops</i> .....	49	<i>subocularis</i> , <i>Typhlops</i> .....	43, 53
<i>diversus</i> , <i>Typhlops</i> .....	49	<i>torresianus</i> , <i>Ramphotyphlops</i> .....	52
<i>dominicanus</i> , <i>Typhlops</i> .....	47	<i>torresianus</i> , <i>Typhlops</i> .....	52
<i>endoterus</i> , <i>Ramphotyphlops</i> .....	46	<i>tovelli</i> , <i>Ramphotyphlops</i> .....	49
<i>endoterus</i> , <i>Typhlops</i> .....	49	<i>trangensis</i> , <i>Typhlops</i> .....	47
<i>grypus</i> , <i>Ramphotyphlops</i> .....	46, 49, 50	<i>troglodytes</i> , <i>Ramphotyphlops</i> .....	53
<i>grypus</i> , <i>Typhlops</i> .....	43, 49	<i>Typhlops</i> .....	46, 47, 53
<i>guentheri</i> , <i>Ramphotyphlops</i> .....	49	<i>unguirostris</i> , <i>Ramphotyphlops</i> .....	47, 50, 51, 52, 53
<i>guentheri</i> , <i>Typhlops</i> .....	49	<i>unguirostris</i> , <i>Typhlops</i> .....	52
<i>hypogius</i> , <i>Typhlops</i> .....	47	<i>waitii</i> , <i>Ramphotyphlops</i> .....	48
<i>infralabialis</i> , <i>Typhlops</i> .....	53	<i>wiedii</i> , <i>Ramphotyphlops</i> .....	43, 46, 48, 52, 53
<i>kenti</i> , <i>Typhlops</i> .....	50	<i>wiedii</i> , <i>Typhlops</i> .....	46, 52, 53
<i>kimberleyensis</i> , <i>Ramphotyphlops</i> .....	53	<i>wilsoni</i> , <i>Typhlops</i> .....	47, 48
<i>klemmeri</i> , <i>Typhlops</i> .....	47	<i>Xenotyphlops</i> .....	47
<i>kraali</i> , <i>Typhlops</i> .....	47	<i>yirrikalae</i> , <i>Ramphotyphlops</i> .....	43, 47

# **The Scincid Lizard Genus *Caledoniscincus* (Reptilia: Scincidae) from New Caledonia in the Southwest Pacific: A Review of *Caledoniscincus austrocaledonicus* (Bavay) and Description of Six New Species from Province Nord**

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**ABSTRACT.** The status of the New Caledonian scincid lizard *Caledoniscincus austrocaledonicus* (Bavay) is reviewed and found to comprise two species. The species conspecific with the designated neotype is widespread and morphologically diverse, the other is conspecific with *Euprepes haplorhinus* Günther and is also widespread in distribution. These two species occur in sympatry over much of their range, particularly on the west coast. Six new species of *Caledoniscincus* are described from the central and northern regions of the island, bringing to eleven the total number of species in the genus. The new species are restricted to closed forest habitat and have limited distributions, hence they are all regarded as vulnerable to disturbance of this habitat type. The eight species dealt with in this paper are recognised on the basis of combined morphological and genetic (allozyme) analysis of 36 populations representing all members in the genus.

SADLIER, ROSS A., AARON M. BAUER & DON J. COLGAN, 1999. The scincid lizard genus *Caledoniscincus* (Reptilia: Scincidae) from New Caledonia in the Southwest Pacific: a review of *Caledoniscincus austrocaledonicus* (Bavay) and description of six new species from Province Nord. *Records of the Australian Museum* 51(1): 57–82.

Some of the most common and widespread elements of the New Caledonian lizard fauna are the small scincid species in the genus *Caledoniscincus*. The last revision of the genus (Sadlier, 1986) identified four species, *C. austrocaledonicus*, *C. atropunctatus*, *C. festivus*, and *C. orestes*, all characterised

by marked sexual dimorphism in colour and pattern. *Caledoniscincus austrocaledonicus*, *C. festivus* and *C. atropunctatus* are widespread throughout the island, whereas *C. orestes* at the time of description (1986) was only known from mid-high (600–1,400 m asl) habitats on



Mt Panié in the northeast ranges. The four species were distinguished from one another mainly by coloration (particularly that of males) and size.

Extensive field research in New Caledonia over the past 5 years has revealed *Caledoniscincus* to be a far more diverse group than previously suspected. The widespread species *C. austrocaledonicus* has been found to comprise two species, one of which is conspecific with *Euprepes haplorhinus* Günther (formerly a synonym of *C. austrocaledonicus*). In the central and northern regions of the island six new taxa are known from areas of closed forest habitat. Several of the undescribed species are known from only single localities or small geographical areas, while the remainder are restricted to larger, but still discrete regions. In a south to north order the new species described are: *C. cryptos* known only from a single specimen in the central ranges (near Col d'Amieu); *C. renevieri* known from several localities in the central ranges (Col des Roussettes, Mt Aoupinié, and Grottes des Adio); *C. chazeau* from one, possibly two, locations near limestone outcrops on the northeast coast (near Hienghène); *C. aquilonius* from a number of localities in the northern ranges; *C. auratus* from one, possibly two, locations near limestone outcrops on the northwest coast (near Koumac); and *C. terma* known only from Mt Mandjélia at the northern tip of the northeast ranges. Because of the localised nature of their distributions and the range of threats to closed forest habitat in New Caledonia, most of the new taxa described in this paper are considered to be of particular conservation concern.

### Materials and methods

Abbreviations. Institutional abbreviations are as follows: Australian Museum (AMS); The Natural History Museum, London (BMNH); California Academy of Sciences (CAS); Naturhistorisches Museum, Basel (NHMB); Muséum national d'Histoire naturelle, Paris (MNHN).

The full suite of morphological characters listed below were scored for each specimen where possible. For each character the abbreviation used in Table 3 is given in parentheses.

Measurements. Snout to vent length (SVL)—measured from tip of snout to caudal edge of anal scales; axilla to groin distance—measured from middle of base of forelimb to middle of base of hindlimb; forelimb to snout length—measured from tip of snout to middle of base of forelimb; hindlimb length—measured from middle of base of hindlimb to tip of fourth toe including nail; tail length (TL)—measured from caudal edge of anal scales to tip of tail, on complete original tails only. Body measurements (axilla to groin, forelimb to snout, hindlimb, and tail lengths) are for adults only, as determined by reproductive maturity (presence of enlarged yolked ovarian follicles or eggs in females, and presence of enlarged testes and distinctive coloration in males) and/or obvious size classes, and are expressed as percentages of snout to vent length in the taxon accounts.

Scalation. Midbody scale rows (MBR)—number of longitudinal scale rows around body counted midway between axilla and groin; paravertebral scales (DSR)—

number of scales in a paravertebral row from first scale posterior to parietal scale to last scale at level of vent opening; fourth finger and toe scales—number of dorsal scales on fourth digit of hand and foot, distal scale contains claw and basal scale broadly contacts adjacent basal scale of third finger or toe; fourth finger and toe lamellae—number of ventral scales on fourth digit of hand and foot, distal scale contains claw and basal scale is last largely undivided scale at, or proximal to, a point level with intersection of third and fourth digits. Bilateral scalation characters were scored on both sides and the mean value used in description of each species; in the holotype descriptions these values are presented as left/right values. Sexual dimorphism in paravertebral scales (the scalation character most likely to exhibit this trait) was assessed using independent two-sample *t*-test in those species represented by a moderately large sample size ( $\geq 10$  specimens with approximately equal numbers of each sex). Variation between populations was assessed using independent two-sample *t*-tests for all scalation characters. However, only characters with a high *P* value ( $P \leq 0.001$ ) are given in the comparison of species as these most likely reflect unambiguous species level differences.

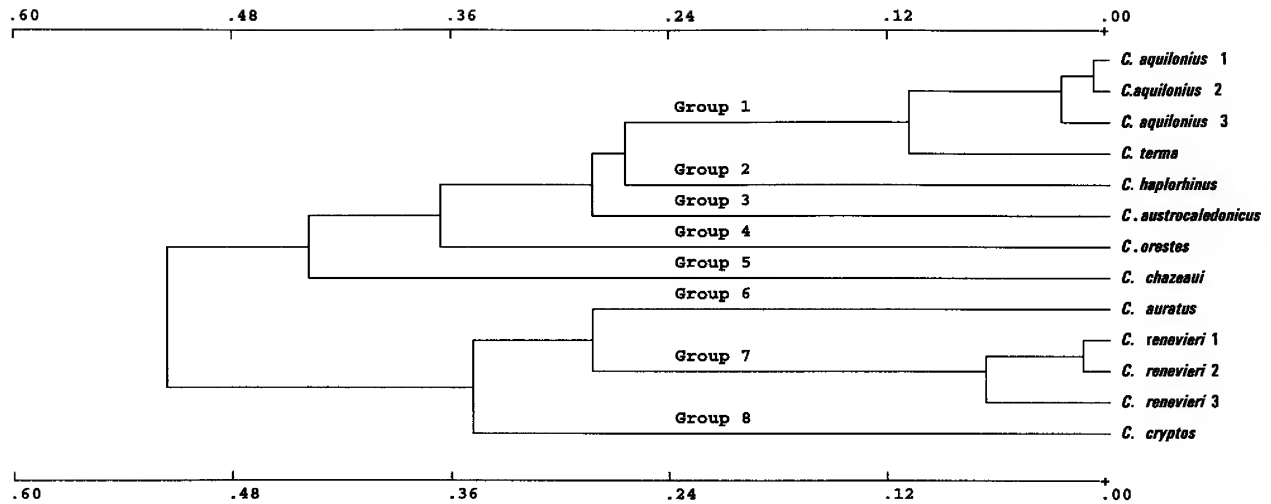
Osteology. Specimens were X-rayed for counting the number of presacral vertebrae and postsacral vertebrae (complete original tails only).

Electrophoretic methods. Standard methods for cellulose acetate electrophoresis of liver homogenates on TITAN III plates (Helena Laboratories) were used to assess genetic relationships between populations (Hebert & Beaton, 1989; Colgan & Flannery, 1992; Sadlier *et al.*, 1993). Where more than one locus encoding the same enzyme was found, they are designated numerically in order of decreasing anodal mobility. Allozymes are designated (alphabetically) in the same fashion for each locus. The computer package BIOSYS-1 (Swofford & Selander, 1981) was used to calculate genetic distances and to perform cluster analyses. Where *Idhp-1* was not seen in the phenotype of a population, it was scored as being homozygous null (with a dummy allelic designation in BIOSYS-1) for the purposes of distance calculations.

### Results

The electrophoretic results are presented in Tables 1 and 2. Table 1 shows the number of individuals scored from each population of the species described herein and from *Caledoniscincus orestes*. In both Tables 1 and 2 *C. austrocaledonicus* and *C. haplorhinus* are each represented by pooled populations. A more detailed account of variation in *C. austrocaledonicus* will be presented elsewhere. The names of the scored enzymes, together with abbreviations and Enzyme Commission Numbers are also listed in Table 1, and a matrix of genetic distances between *Caledoniscincus* populations is given in Table 2. A UPGMA dendrogram of genetic distances between populations is shown in Figure 1. Eight groups can be clearly distinguished. The Nei Unbiased distance between any pair of populations from different groups is at least 0.25.





**Figure 1.** UPGMA dendrogram of relationships between *Caledoniscincus* populations based on Nei's unbiased genetic distance. Population names are the same as in Table 1.

Group 1 includes 4 populations from the far north of the island separated from group 2, the next most genetically similar group, by a Nei unbiased genetic distance of 0.27. Within group 1 are two subgroups (with a Nei unbiased genetic distance of 0.10) that are here described as two species on the basis of consistent morphological differences (coloration, scalation, osteology) between the type populations of each species. The first species, *Caledoniscincus aquilonius*, is represented in the genetic study by three populations, one from Koumac (*C. aquilonius* 1), one from Mt Panié (*C. aquilonius* 2) here designated as the type population, and the third from Kavaatch (*C. aquilonius* 3); the second species, *Caledoniscincus terma*, consists of a single population from Mt Mandjélia.

Groups 2 and 3 comprise those populations formerly assigned to *Caledoniscincus austrocaledonicus*. Our studies show *C. austrocaledonicus* to be a single widespread species that exhibits marked dimorphism in colour and pattern between northern and southern populations. A second widespread species, *Caledoniscincus haplorhinus*, occurs in open coastal and near coastal habitats, mainly on the west coast of the island, but also at scattered localities on the east coast and in the Loyalty Islands. *Caledoniscincus haplorhinus* is similar in size and appearance to *Caledoniscincus austrocaledonicus* from the north and central regions of the island, most notably in also having a white midlateral stripe. Both species are regionally and often locally sympatric along the west coast. The formal recognition of these genetic groups as distinct species is supported by differences in adult male ventral coloration and the positioning and delineation of the white midlateral stripe.

Group 2 represents *Caledoniscincus haplorhinus* (5 populations pooled—all from the west coast of the island).

Group 3 represents *Caledoniscincus austrocaledonicus* s.str. (20 populations pooled) as defined above.

Group 4 represents *Caledoniscincus orestes* from Mt Panié on the northeast ranges as defined by Sadlier (1986).

Groups 5, 6, and 7 are recognised as distinct species on the basis of a combination of scalation and electrophoretic criteria, while group 8 (a single adult male) is currently recognised solely on electrophoretic criteria.

Group 5 (*Caledoniscincus chazeau*) represents a population from closed forest in the area of limestone rock outcropping on the northeast coast near Hienghène. Group 5 is separated from groups 1 to 4 by a Nei unbiased distance of 0.44.

Groups 6–8 form a discrete cluster separated from groups 1–5 by a Nei unbiased distance of 0.51.

Group 6 (*Caledoniscincus auratus*) consists of a single population from Koumac (where it is sympatric with *C. aquilonius* 2) on the northwest coast. Group 6 is separated from group 7, the next most genetically similar group, by a Nei unbiased distance of 0.28.

Group 7 (*Caledoniscincus renevieri*) comprises three populations in the central ranges of the island: Mt Aoupinié (*C. renevieri* 1), Grottes des Adio (*C. renevieri* 2), and Col des Roussettes (*C. renevieri* 3).

Group 8 (*Caledoniscincus cryptos*), represented by a single individual from near Col d'Amieu in the central ranges, is separated from those populations in the group 6 + 7, the next most genetically similar group, by a Nei unbiased distance of 0.35.

Whilst genetic distances give a general idea of a population's affinities, inspection of the allozymic frequency data is required for a clearer picture. Notably, each of the groups defined above (except groups 1 and 6) are fixed, for at least one locus, for an allozyme which is seen nowhere else in the data. For Group 2 (*C. haplorhinus*) such allozymes are found at both *Idhp-1* and *Idhp-2*, for Group 3 (*C. austrocaledonicus*) at *Aat-1*, for Group 4 (*C. orestes*) at *Fh-2* and *Idhp-2*, for Group 5 (*C. chazeau*) at *Aat-1*, for Group 7 (*C. renevieri*) at *Idhp-1*, and for Group 8 (*C. cryptos*) at *Gapdh*. Inspection of the data in Table 1 reveals sufficient fixed differences ("fds") between groups (with the possible exception of *C. aquilonius* and *C. terma*)

to support all of the taxonomic decisions made below. For instance, *C. aquilonius* and *C. terma* are differentiated from Group 2 by fds at *Gpd*, *Idhp-1*, *Idhp-2* and (nearly fixed) *Pgm*. *Caledoniscincus renevieri* and *C. auratus* are differentiated by fds at *Idhp-1*, *Pep:LA*, *Pep:LGG* and *Pgdh*. *Caledoniscincus cryptos* is distinguished from both of these species by fds at *Fbp*, *Gapdh* and *Gpd*. There are two fds between the morphospecies *C. aquilonius* and *C. terma* (*Idhp-2* and *Pgdh*) and the GPI C allozyme which is common, but not abundant, in the former is apparently absent from the latter.

### Species descriptions

The species dealt with in this paper are small to moderately large in size, with well-developed limbs and digits, long tails, an obvious ear opening, and share the following basic suite of scalation characters: frontonasal broader than long; prefrontals when present moderately large and widely separated; frontal almost as broad as long; supraoculars four; frontoparietals fused; interparietal distinct; parietal bordered by a nuchal and upper secondary temporal; primary temporal single; upper and lower secondary temporals single; tertiary temporals two; postlabials two; nasals moderately to widely separated; loreals two, in a horizontal sequence; upper and lower preocular present; supraciliaries usually 7; upper labials usually 7; lower labials 6; postmental contacting first and second lower labials; enlarged chinshields three, first pair in broad contact; lower eyelid with an obvious, centrally located semi-transparent disc; ear opening with enlarged auricular lobules anteriorly and

numerous blunt conical scales around the upper, lower, and posterior edges; body scales of dorsal and lateral surfaces tricarinate, each keel usually interrupting the posterior scale edge, number of keels on dorsal scales increasing towards nape. All species also have 29 presacral vertebrae (occasionally 28 or 30) and a phalangeal formula for the manus and pes of 2.3.4.5.3 and 2.3.4.5.4 respectively.

The species accounts below describe variation in proportions, and certain features of scalation, osteology, and coloration for each species, and report on their distribution and habits.

### *Caledoniscincus austrocaledonicus* (Bavay)

Figs. 2, 3

*Lygosoma austro-caledonica* Bavay, 1869: 21.

*Lygosoma austro-caledonicum dorsovittatum* Roux, 1913: 118.

*Leiolopisma dorsovittatum bodoi* Borner, 1980: 8.

Problems in resolving the taxonomy of *Caledoniscincus austrocaledonicus* stem from the sexual and regional variability in coloration in this species, its occurrence in the north of the island with a closely related and morphologically very similar species, and the apparent loss of the specimens upon which the original description was based. The history of synonyms for this species are presented chronologically below.

The description of *Lygosoma austro-caledonica* by Bavay (1869) is composite (Sadler, 1986) in that it identifies two forms. It was one of eight new scincid



Figure 2. *Caledoniscincus austrocaledonicus* male (upper) and female (lower) from Mt Aoupinié.

lizards described by him from New Caledonia for which no types were designated at the time of description, nor any indication as to where the specimens on which the descriptions were based were lodged.

The species *Euprepes haplorhinus* described by Günther (1872) from the Fiji Islands was placed in the synonymy of *L. austro-caledonicum* by Boulenger (1887) and the locality of “Fiji” was indicated as being in error for New Caledonia.

The first major revision of the New Caledonian herpetofauna was by Roux in 1913, based mainly on collections made by Roux and Sarasin in New Caledonia in 1911. Roux recognised four subspecies in *Lygosoma austro-caledonicum*. In addition to the nominate form, Roux described three new subspecies: *Lygosoma austro-caledonicum dorsovittatum*; *Lygosoma austro-caledonicum atropunctatum*; and *Lygosoma austro-caledonicum festivum*. Roux considered *Lygosoma austro-caledonicum atropunctatum* represented one of the forms of *Lygosoma austro-caledonica* described by Bavay (1869), and *Euprepes haplorhinus* Günther (1872) a synonym of *Lygosoma austro-caledonicum*. Kramer (1979) subsequently designated lectotypes for all Roux’s subspecies of *Lygosoma austro-caledonicum*.

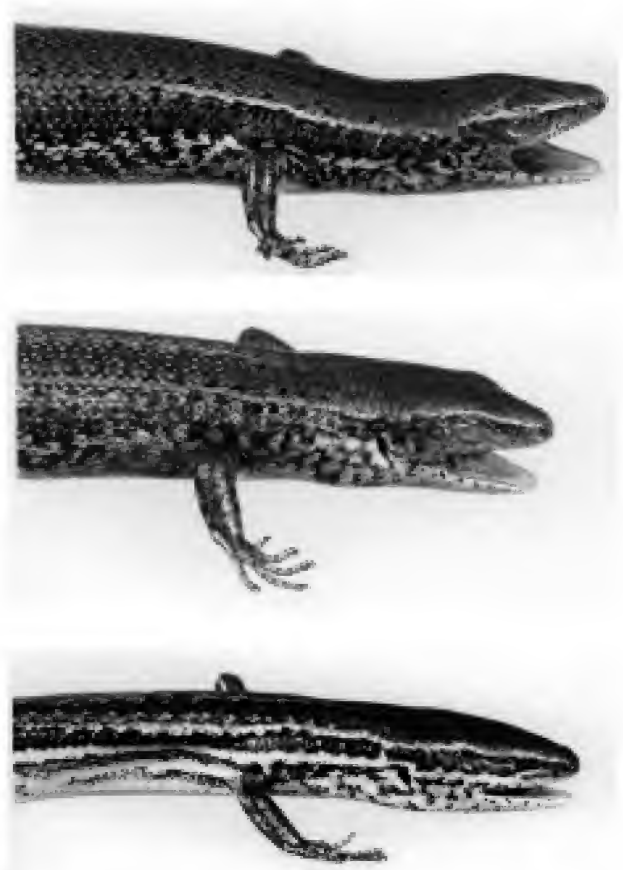
Borner (1980) described the subspecies *Leiolopisma dorsovittatum bodoi* from the Ile des Pins.

Brygoo (1985) published a catalogue of scincid types in the Paris Museum which included a number of Bavay type specimens that had until that time been regarded as lost (Sadlier, 1986). However the types of *Lygosoma austro-caledonicum* Bavay were not among those listed.

Sadlier (1986) reviewed the taxonomy of *Caledoniscincus* and proposed a neotype for *Lygosoma austro-caledonicum* Bavay, an adult female from Mt Aoupinié in the central ranges. In colour and pattern this specimen is typical of females found in populations occurring in the central and northern ranges and coast of New Caledonia. Roux’s subspecies *Lygosoma austro-caledonicum atropunctatum* and *Lygosoma austro-caledonicum festivum* were recognised as distinct species by Sadlier (1986), and *Euprepes haplorhinus* Günther, *Lygosoma austro-caledonicum dorsovittatum* Roux, and *Leiolopisma dorsovittatum bodoi* Borner were all placed in the synonymy of *C. austrocaledonicus*.

The research presented here clearly identifies *Lygosoma austro-caledonicum* Bavay and *Euprepes haplorhinus* Günther as distinct species. *Lygosoma austro-caledonicum dorsovittatum* Roux and *Leiolopisma dorsovittatum bodoi* Borner are regarded here as conspecific with *Lygosoma austro-caledonicum* Bavay.

**Material examined.** All from Mt Aoupinié as follows: AMS R77643–45, R77649 forestry camp, 21°09'S 165°20'E; R77690, R77692 2 km NE of Mt Aoupinié forestry camp by road, 21°08'S 165°21'E; R77707, R77710–14, R146369 creek crossing 1 km NE of forestry camp by road, 21°08'S 165°20'E; R77739–40, R77755–56, R146379 summit, 21°11'S 165°16'E; R77757 (NEOTYPE), R77758 4 km from summit by road, 21°11'S 165°16'E; R77759–61 6 km from summit by road, 21°11'S 165°16'E; R146376–77 creek 1.3 km below logging camp, 21°08'S 165°20'E; R146386 1.5–2.5 km below logging camp, 21°07'S 165°19'E.



**Figure 3.** Lateral view of *Caledoniscincus austrocaledonicus* (upper and middle) and *Caledoniscincus haplorhinus* (lower) showing positioning of pale midlateral stripe in region of ear opening.

**Diagnosis.** *Caledoniscincus austrocaledonicus* is a widespread and morphologically variable species that shows variation in coloration between sexes and between populations in the south and north of the main island. It can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size (39–57 mm SVL); (b) tail approximately 1.5 times longer than body; (c) midbody scales in 28–32 rows; (d) paravertebral scales in 56–65 rows; (e) postsacral vertebrae >46; (f) adult males with pale vertebral markings and usually a broad, pale dorsolateral margin; (g) lateral surface with (northern and central populations) or without (southern) a pale midlateral stripe; (h) rostral shield with a dark midrostral streak; (i) adult males with an orange flush to the ventral surface in life. Note that estimates of tail length and postsacral vertebrae number are derived from populations other than those represented in Table 3.

This combination of characters distinguishes *Caledoniscincus austrocaledonicus* from all other members of the genus with the exception of *C. haplorhinus*. *Caledoniscincus austrocaledonicus* from the northern and central regions of the island are very similar in size, scalation, and certain aspects of coloration to *C.*



*haplorhinus*, most notably in also having a pale midlateral stripe. However, in *C. austrocaledonicus* from the northern and central regions of the island this stripe is usually poorly defined or obscure in the area between the forelimbs and ear opening (Fig. 3), and when obvious anteriorly this stripe meets the ear opening at the posteromedial edge. In contrast, the pale midlateral stripe in *C. haplorhinus* is usually well defined along its entire length and meets the ear at the upper or posteromedial edge of the ear and extends forward to form a pale edging over the ear (Fig. 3). The ventral colour in life of adult male *C. austrocaledonicus* is usually orange whereas adult male *C. haplorhinus* usually have yellow venters. *Caledoniscincus terma* is similar to *C. austrocaledonicus* from the southern regions of the island in having pale vertebral markings and no pale midlateral stripe. However, *C. austrocaledonicus* from this region have a longer tail (>45 vs 35–38 postsacral vertebrae or a tail length of  $\approx 150$  vs 130–140% SVL) than *C. terma*, and the ventral colour in life of adult male *C. austrocaledonicus* is usually orange vs usually yellow in adult male *C. terma*.

**Description.** It is beyond the scope of this study to analyse inter and intra population variation in scalation or osteology in *C. austrocaledonicus*. The data presented in the following description is based on 28 specimens (16 males and 12 females) from the neotype population (including the neotype) at Mt Aoupinié in the central ranges (*C. austrocaledonicus* [north] of Table 3).

**Measurements:** adult size 44–57 mm SVL; distance from axilla to groin 52.9–61.4% of SVL ( $\bar{x}$  = 56.6,  $n$  = 28); distance from forelimb to snout 33.3–41.3% of SVL ( $\bar{x}$  = 37.7,  $n$  = 28); hindlimb length 33.3–46.8% of SVL ( $\bar{x}$  = 41.2,  $n$  = 28); tail length approximately 150% of SVL estimated from individual with most complete tail.

**Scalation.** midbody scales in 30–32 rows ( $\bar{x}$  = 31.2,  $SD$  = 0.99,  $n$  = 28); paravertebral scales in 58–65 rows ( $\bar{x}$  = 61.2,  $SD$  = 1.84,  $n$  = 28), no significant variation ( $P$  value  $\leq 0.05$ ) between males and females ( $\bar{x}$  = 61.2 vs 61.3,  $t_{26}$  = -0.204,  $P$  = 0.840); dorsal scales of fourth finger 11–12 ( $\bar{x}$  = 11.3,  $SD$  = 0.40,  $n$  = 28); lamellae of fourth finger 15–18 ( $\bar{x}$  = 16.5,  $SD$  = 0.69,  $n$  = 28); dorsal scales of fourth toe 16–19 ( $\bar{x}$  = 17.0,  $SD$  = 0.56,  $n$  = 28); lamellae of fourth toe 26–33 ( $\bar{x}$  = 28.7,  $SD$  = 1.74,  $n$  = 28).

**Osteology.** Presacral vertebrae 29 ( $n$  = 15), rarely 28 ( $n$  = 1); no specimens with complete, original tails in sample to assess postsacral vertebrae number but specimen with most complete original tail has >50 postsacral vertebrae.

**Coloration.** *Caledoniscincus austrocaledonicus* shows marked sexual dimorphism in base colour of the dorsal and lateral surfaces. In males the dorsal and lateral colour is similar and the ventral surface usually red-orange. In females the dorsal surface is lighter than the lateral surface i.e. markedly two-toned, and the ventral surface is usually yellow. Juveniles and subadults of both sexes have the colour and pattern of adult females. The colour description below is based on specimens from the neotype locality at Mt Aoupinié in the central ranges, but is broadly applicable to other populations of *C. austrocaledonicus* in the central and northern regions of the island.

**Males:** dorsal surface of body mid to dark brown with numerous pale flecks and distinctive pale vertebral

markings, grey-brown in colour, rough-edged, and extending variably from nape to mid-dorsum as a stripe ( $\approx 1$  scale wide) before breaking into a series of poorly connected elongate blotches over posterior half of body; head lighter than dorsum, with a coppery flush and dark longitudinal streak on rostrum. Dorsolateral margin pale (usually colour same as pale vertebral markings), moderately broad ( $\approx 1$ –1.5 scales wide), and forming a conspicuous rough-edged stripe from rostral to and along the basal portion of tail, distinct from both dark dorsal and upper lateral colour. Lateral surface mid-dark brown and with a pale midlateral stripe; upper lateral surface similar to dark dorsal colour but darker than lower lateral surface; pale midlateral stripe rough-edged and extending from level of ear opening to base of hindlimb (sometimes broken by an extension of dark brown colour of forelimb onto adjacent lateral surface), usually poorly defined or obscure in area between forelimbs and ear opening, when obvious anteriorly pale midlateral stripe meets ear opening at posteromedial edge; area above and in front of ear opening same as adjacent lateral surface, occasionally with numerous white markings which coalesce around upper edge of ear opening (resembling the extension of pale midlateral stripe characteristic of *C. haplorhinus* but not as well defined or complete). Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs orange, continuing variably along underside of tail.

**Females:** dorsal surface light to mid brown; laterodorsal margin (scale row 3) with dark markings to every second or third scale to give appearance of a longitudinal series of dark flecks, dorsolateral edge distinct, variably with a pale (lighter than adjacent dorsal colour), narrow (less than a scale width), margin. Lateral surface mid-dark brown (contrasting markedly with adjacent dorsal surface) and with a pale midlateral stripe; upper lateral surface darker than lower; pale midlateral stripe clean-edged and extending from level of ear opening to base of hindlimb, definition of pale midlateral stripe as for males (above). Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs yellow, continuing variably along underside of tail.

**Variation.** Data in Table 3 indicate populations of *Caledoniscincus austrocaledonicus* from the south of the species range tend to be smaller in size, have fewer midbody scale rows and paravertebral scales, and in coloration lack a pale midlateral stripe.

Regional differences in the presence or absence of a pale midlateral stripe in *Caledoniscincus austrocaledonicus* have confused previous taxonomies. Populations which share the coloration characteristics of the neotype (a well-developed midlateral stripe) extend throughout the central and northern regions of the island, the southernmost populations occurring at Voh on the west coast, Col des Roussettes in the central mountain chain, and Houaïlou on the east coast. In the central mountain chain populations immediately south of Col des Roussettes have this coloration characteristic poorly expressed (males lack a pale midlateral stripe but some females have a poorly defined stripe), and those that occur in the south of the island (this is the area at and south of the northern limit of the extensive southern ultramafic



region), the Ile des Pins, and the Loyalty Islands do not have this coloration characteristic.

**Details of neotype.** Adult female; size 53 mm SVL; distance from axilla to groin 32 mm; distance from forelimb to snout 19 mm; hindlimb length 19 mm; tail length 66 mm, regenerated.

Midbody scales rows 30; paravertebral scale rows 59; dorsal scales of fourth finger 11/12; lamellae of fourth finger 16/16; dorsal scales of fourth toe 16/16; lamellae of fourth toe 27/27.

**Distribution.** The species is widespread throughout New Caledonia and the islands of the region including the Ile des Pins, and Ouvéa, Lifou, and Maré in the Loyalty Islands group.

**Biology.** *Caledoniscincus austrocaledonicus* occurs throughout a wide range of forest and shrubland habitats across a broad altitudinal range. It is most commonly observed at the forest edge or in sunlit patches on the forest floor, but also occurs in coastal scrubs and maquis shrubland habitat. It is sympatric with *C. haplorhinus* at various lowland localities in both the north and south of New Caledonia and the islands of the region. In the north of the island the two species are sympatric at several mid-high altitude locations. Where the two species do occur at the same location, *C. austrocaledonicus* inhabits the forest edge and open areas of the forest interior, whereas *C. haplorhinus* occurs in more open adjacent habitat and tends to be extralimital at the forest edge. In such situations both species are syntopic at the forest edge.

**Comments.** The description of *Caledoniscincus austrocaledonicus* by Sadlier (1986) was composite and contained specimens of *C. haplorhinus*.

**Other material examined.** With the exception of tail length and postsacral vertebrae the values presented in Table 3 for *C. austrocaledonicus* from the south of the island (austro sth.) are taken from the following material: AMS R77442–43, R77445, R77448, R78309, R78311–12, R78315, R78324 Nouméa, Fambourg Blanchot (rue de Capitain Ferraud), 20°18'S 166°27'E; R77470 Nouméa, Mont-Coffyn, 20°18'S 166°27'E. Values for tail length and postsacral vertebrae presented in Table 3 are taken from a sample of two specimens from Plateau de Dogny.

### *Caledoniscincus haplorhinus* Günther

Figs. 3, 4

*Euprepes haplorhinus* Günther, 1872: 419.

**Type material.** HOLOTYPE: BMNH 1946.8.13.45.

**Material examined.** AMS R77407, R77409, R77427, R77437, R77449–52, R 78319–20, R78322, R78326–28 Nouméa, Fambourg Blanchot, 20°18'S 166°27'E; AMS R135119–23 Isle Nou, vicinity Nouville, 22°16'S 166°24'E; AMS R146433–43, CAS 198763–71 Plage de Ouano, 21°50'S 165°48'E; AMS R144257–58, R144284–93 Koumac Caves, approx. 9 km E of

Koumac, 20°33'S 164°21'E; AMS R146459–72 Pindaï, Plage de Pindaï, 21°21'S 164°57'E.

**Diagnosis.** *Caledoniscincus haplorhinus* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size (42–55 mm SVL); (b) tail approximately 1.65 times longer than body; (c) midbody scales in 28–32 rows; (d) paravertebral scales in 59–67 rows; (e) postsacral vertebrae >50; (f) adult males with pale vertebral markings and broad pale dorsolateral margin; (g) lateral surface with a pale midlateral stripe; (h) rostral shield with a dark midrostral streak; (i) adult males with a yellow flush to ventral surface in life.

**Description.** the description is based on 61 specimens (51 adults and 10 subadults) and includes samples from four (Isle Nou, Plage de Ouano, Koumac Caves and Pindaï) of the five populations used in the electrophoretic study.

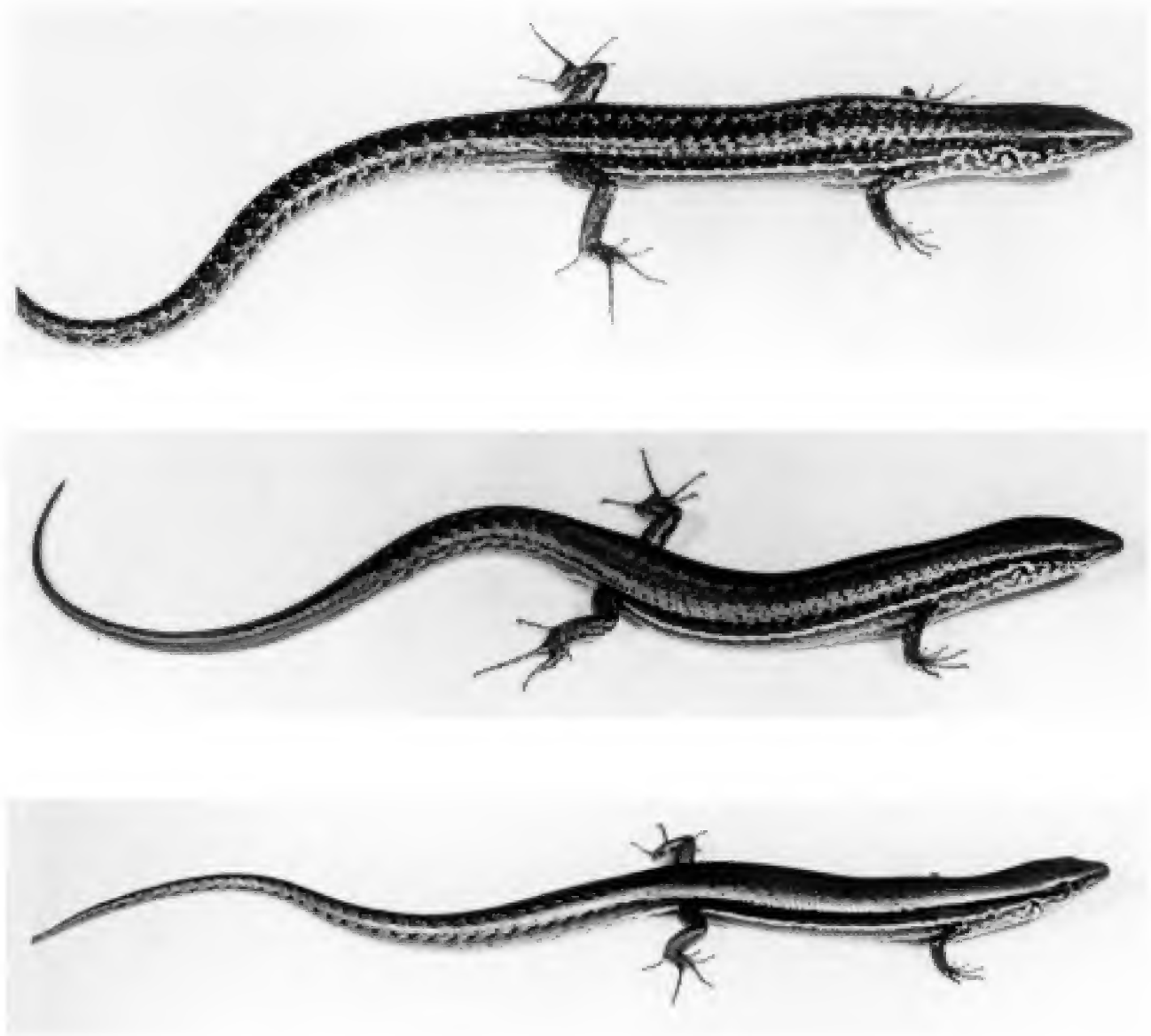
**Measurements.** Maximum adult size 55 mm SVL; distance from axilla to groin 51.0–63.3% of SVL ( $\bar{x}$  = 57.0,  $n$  = 50); distance from forelimb to snout 34.7–40.4% of SVL ( $\bar{x}$  = 37.6,  $n$  = 50); hindlimb length 33.3–42.5% of SVL ( $\bar{x}$  = 38.8,  $n$  = 49); tail length 156.0–173.5% of SVL ( $\bar{x}$  = 165.1,  $n$  = 4—note this includes 3 adults with nearly complete tail only).

**Scalation.** Midbody scales in 28–32 rows ( $\bar{x}$  = 30.0,  $SD$  = 1.06,  $n$  = 61); paravertebral scales in 59–67 rows ( $\bar{x}$  = 63.0,  $SD$  = 1.63,  $n$  = 61) significant variation ( $P$  value  $\leq 0.05$ ) between males and females ( $\bar{x}$  = 62.5 vs 63.5,  $t_{49}$  = -2.535,  $P$  = 0.014); dorsal scales of fourth finger 10–12 ( $\bar{x}$  = 10.9,  $SD$  = 0.62,  $n$  = 60); lamellae of fourth finger 14–18 ( $\bar{x}$  = 15.8,  $SD$  = 0.67,  $n$  = 60); dorsal scales of fourth toe 14–18 ( $\bar{x}$  = 16.6,  $SD$  = 0.91,  $n$  = 60); lamellae of fourth toe 25–31 ( $\bar{x}$  = 28.0,  $SD$  = 1.38,  $n$  = 60).

**Osteology.** Presacral vertebrae 29 ( $n$  = 12); postsacral vertebrae 51 ( $n$  = 2) to 55 ( $n$  = 1).

**Coloration.** Males: dorsal surface mid to dark brown with numerous pale flecks and distinct pale vertebral markings, grey-brown in colour, rough-edged, and extending from nape to mid-dorsum as a stripe before breaking into a series of poorly connected elongate blotches over posterior half of body; head lighter than dorsum, with a coppery flush and dark longitudinal streak on rostrum. Dorsolateral margin pale (grey-brown similar to pale vertebral markings), moderately broad ( $\approx 1$ –1.5 scales wide), and forming a conspicuous rough-edged stripe from rostral to and along basal portion of tail, distinct from both dark dorsal and upper lateral colour. Lateral surface mid-dark brown and with a pale midlateral stripe, upper lateral surface darker than lower lateral surface (darker than or similar to dorsal colour); pale midlateral stripe (usually dark edged) well defined along its entire length and extending from level of ear opening to base of hindlimb, meeting ear at upper or posteromedial edge and extending forward to form a pale edging over the ear. Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs with a yellow flush, continuing variably along underside of tail.

Females: dorsal surface light to mid brown, occasionally grey, uniform or with variably distinct pale vertebral



**Figure 4.** *Caledoniscincus haplorhinus* males from Pindaï (upper) and Koumac (middle), and female from Koumac (lower).

markings, grey-brown in colour, and extending from nape to mid-dorsum as a stripe before breaking into a series of poorly connected elongate blotches over posterior half of the body. Lateral surface mid-dark brown (darker than and contrasting markedly with adjacent dorsal colour) with a pale midlateral stripe, upper lateral surface darker than lower lateral surface; pale (dark edged) midlateral stripe clean-edged, extending from level of ear opening to base of hindlimb, and positioned to meet ear as described for males. Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs pale yellow, continuing variably along underside of tail.

Juveniles and subadults of both sexes have coloration of adult females, and dorsal and lateral surfaces and pale midlateral stripe well defined.

**Variation.** Samples of both sexes from beachfront locations can be paler overall in coloration, grey replacing brown as the background tone. In some adults from these locations the definition of the pale midlateral stripe is poor anteriorly and its position relative to the ear opening difficult to assess.

**Details of holotype.** Adult male; size 50 mm SVL; distance from axilla to groin 28 mm; distance from forelimb to snout 19 mm; hindlimb length 21 mm; tail length 64 mm, regenerated.

Midbody scales rows 28; paravertebral scale rows 62; dorsal scales of fourth finger 11/11; lamellae of fourth finger 17/17; dorsal scales of fourth toe 17/17; lamellae of fourth toe 29/28.

**Distribution.** Widespread in coastal and near coastal areas of the west coast of New Caledonia, and scattered locations on the east coast from near Ouaième in the north to Houailou midway along the coast. Also recorded from two mid altitude sites ( $\approx 500$  m asl) and one high altitude site ( $\approx 1,000$  m asl on Mt Ignambi) in the northeast ranges. Widespread throughout the islands of the region including the Ile des Pins off southern New Caledonia, Ouvéa, Lifou, and Maré Islands of the Loyalty Islands group, and Ile Surprise off northern New Caledonia.

**Biology.** Occurs in open coastal and near coastal habitats including grassed, beachfront sand-dunes, edges of forest habitat, and disturbed areas such as plantations and urban gardens.

*Caledoniscincus haplorhinus* is sympatric with *C. austrocaledonicus* at a number of coastal and lowland localities throughout the main island of New Caledonia, and the islands of the region (see comments the account of *C. austrocaledonicus* above).

Gravid females from Plage de Ouano collected in January 1995 had 3 (1/2,  $n = 4$ , SVL 42–48 mm) and 5 (2/3,  $n = 1$ , size not determined) enlarged yolked ovarian follicles, and specimens from Nouméa collected in March 1990 had 2 (1/1,  $n = 2$ , 43–47 mm) shelled oviducal eggs.

**Comments.** The description of *Caledoniscincus austrocaledonicus* by Sadlier was composite and contained specimens of *C. haplorhinus* (see comments the account of *C. austrocaledonicus* above). Specimens refereed to as *C. austrocaledonicus* from Isle Surprise (Bauer *et al.*, 1992) are *C. haplorhinus*.

### *Caledoniscincus aquilonius* n.sp.

Figs. 5, 6

**Type material.** HOLOTYPE: AMS R144200 Mt Panié, New Caledonia, 20°33'27"S 164°47'15"E (R. Sadlier, 20.viii.1994). PARATYPES: AMS R144198–204, R144206–13, R144227–28, CAS 203480–82, MNHN 1997.3331–32 same location as holotype.

**Etymology.** The species name is from the Latin *aquilonius*, meaning northern, alluding to the distribution of this species in the north of New Caledonia.

**Diagnosis.** *Caledoniscincus aquilonius* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size (39–49 mm SVL); (b) tail (average) approximately 1.5 times longer than body; (c) midbody scales in 30–34 rows; (d) paravertebral scales in 54–58 rows; (e) postsacral vertebrae 40–44; (f) adult males with a broad pale laterodorsal margin and dorsal pattern of scattered light flecks; (g) lateral surface without a pale midlateral stripe; (h) rostral shield with a dark midrostral streak; (i) adult males with an orange flush to the ventral surface in life.

**Description.** The description is based on a series of 15 specimens (8 males and 7 females) collected at the type location, and includes specimens used in the electrophoretic study.

**Measurements.** Adult size 39–49 mm SVL; distance from axilla to groin 52.2–59.2% of SVL ( $\bar{x} = 56.2$ ,  $n = 15$ ); distance from forelimb to snout 36.7–41.3% of SVL ( $\bar{x} = 39.2$ ,  $n = 15$ ); hindlimb length 32.7–40.9% of SVL ( $\bar{x} = 37.3$ ,  $n = 12$ ); tail length 146.3–162.8% of SVL ( $\bar{x} = 154.6$ ,  $n = 2$ ).

**Scalation.** Midbody scales in 30–34 rows ( $\bar{x} = 32.2$ ,  $SD = 1.08$ ,  $n = 15$ ); paravertebral scales in 54–58 rows ( $\bar{x} = 55.8$ ,  $SD = 1.65$ ,  $n = 15$ ), no significant variation ( $P$  value  $\leq 0.05$ ) between males and females ( $\bar{x} = 55.3$ ,  $n = 8$  vs 56.4,  $n = 7$ ,  $t_{13} = -1.425$ ,  $P = 0.178$ ); dorsal scales of fourth finger 9–10 ( $\bar{x} = 9.6$ ,  $SD = 0.46$ ,  $n = 15$ ); lamellae of fourth finger 13–16 ( $\bar{x} = 14.4$ ,  $SD = 0.73$ ,  $n = 14$ ); dorsal scales of fourth toe 11–14 ( $\bar{x} = 13.0$ ,  $SD = 0.34$ ,  $n = 14$ ); lamellae of fourth toe 23–27 ( $\bar{x} = 25.2$ ,  $SD = 1.14$ ,  $n = 14$ ).

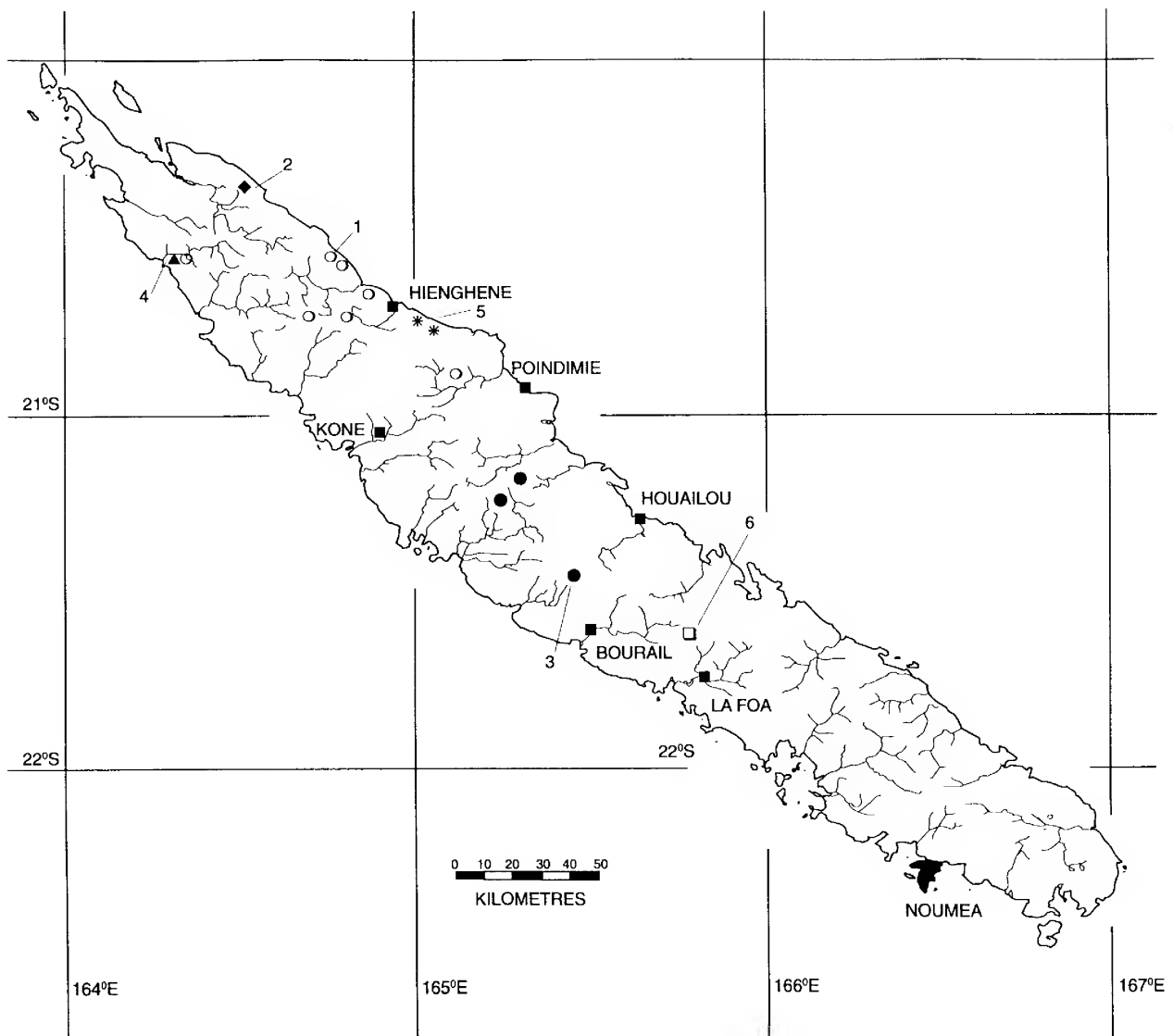
**Osteology.** Presacral vertebrae 29–30 ( $\bar{x} = 29.1$ ,  $SD = 0.26$ ,  $n = 15$ ); postsacral vertebrae 43–44 ( $n = 2$ ).

**Coloration.** Males: dorsal surface variable, background colour ranging from mid brown with numerous pale flecks to more or less uniformly dark brown; pale markings boldest anteriorly around region either side of forelimb and comprising a dark-edged cream fleck on every third longitudinal scale row forming a rough, transversely aligned, pale bar; dorsolateral region grey to pale brown (sometimes darker) with dark flecks, and forming a broad (usually 2 scales wide) and conspicuous pale, rough-edged stripe from rostral to basal portion of the tail. Lateral surface lighter in tone than dorsal, mid-dark brown uppermost with similar pale and dark spotting as dorsal surface, becoming paler towards venter and suffused with orange ventral colour. Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs orange, continuing variably along underside of tail. Throat grey when viewed obliquely but with a faint orange wash when viewed ventrally.

Females: dorsal surface mid to dark brown with occasional fine dark spotting, particularly towards nape; scales on vertebral axis slightly lighter in colour in some individuals and giving the appearance of a faint, pale stripe down the centre of back; head lighter in colour than adjacent dorsal surface. Lateral surface dark brown to black (darker than dorsal surface) becoming paler towards the venter, unmarked or with a few scattered dark markings uppermost, and in larger individuals with a well defined pale dorsolateral margin ( $\approx 1.5$  scales wide). Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs orange, continuing variably along underside of tail. Throat with numerous fine dark specks along the posterior edge of each scale giving an overall grey appearance but with a faint orange wash when viewed ventrally.

**Details of holotype.** Adult male; SVL 44 mm; distance from axilla to groin 25 mm; distance from forelimb to snout 18 mm; hindlimb length 18 mm; tail length 56 mm, reproduced.





**Figure 5.** Distribution of six new species of *Caledoniscincus* in New Caledonia as follows: *Caledoniscincus aquilonius* (○ type locality = 1), *Caledoniscincus terma* (◆ type locality = 2), *Caledoniscincus renevieri* (● type locality = 3), *Caledoniscincus auratus* (▲ type locality = 4), *Caledoniscincus chazeau* (\* type locality = 5), and *Caledoniscincus cryptos* (□ type locality = 6).

Midbody scales rows 32; paravertebral scale rows 56; dorsal scales of fourth finger 10/10; lamellae of fourth finger 14/14; dorsal scales of fourth toe 13/13; lamellae of fourth toe 25/26.

Presacral vertebrae 29.

**Distribution.** The type series is restricted to Mt Panié in the northeast ranges of New Caledonia (Fig. 5). Samples assigned to this species but not included in the type series are known from several other locations in the northeast coast and ranges (Kavaatch in the Hienghène Valley; Ouinguip between Hienghène and the Ouâïème River; Tao near the base of Mt Panié; and upper reaches of the Hienghène Valley) and two extralimital localities, one at Koumac Caves on the northwest coast and one from the main range between

Kone and Poindimié. *Caledoniscincus aquilonius* is probably widespread in closed forest habitat in the north of the island.

**Biology.** Occurs in closed low-mid altitude forest, from near sea level at Tao to 690 m asl on Mt Panié.

Clutch size 3, gravid females (SVL 47 and 48 mm) collected during the summer wet season (January) contained oviducal eggs (1/2, n = 2).

**Comments.** The type series is restricted to the sample of specimens from Mt Panié which unambiguously represented a single species based on the genetic and morphological data are available. In both the Kavaatch and Koumac samples polymorphic allele's with no evidence of





**Figure 6.** *Caledoniscincus aquilonius* male (upper) and female (lower) from Mt Panié.

heterozygotes for the *Gpi* locus were present. While some specimens from each of these samples are regarded as conspecific with the type series, the genetic variation observed in the remaining specimens could be due to the presence of a second cryptic species. For this reason the Kavaatch and Koumac samples are not included in the type series. Several other samples are also here regarded as conspecific with *C. aquilonius* but were collected subsequent to the electrophoretic study and lack genetic data for inclusion in the type series. These samples represent populations from: the upper reaches of the Hienghène Valley; the Roches d'Ouaïème near Ouinguip; and main range between Kone and Poindimié.

The sample from Koumac Caves on the northwest coast (eight specimens included in the electrophoretic study) showed no significant differences in scalation to the type series of *C. aquilonius* from the northeast ranges. Variation in colour and pattern of adult male *C. aquilonius* from Koumac is however more difficult to assess as only a single subadult and single adult male were collected.

Two collections made in the northeast of the island from the upper reaches of the Hienghène Valley and Roches d'Ouaïème between Hienghène and the Ouaïème River were made subsequent to the electrophoretic analysis. These specimens fall within the range of variation in scalation for *C. aquilonius*, and most adult males have the broad pale laterodorsal margin typical of this species; hence they are here assigned to *C. aquilonius*.

A collection of specimens made at mid-altitude on the main range between Kone and Poindimié, is most similar to *C. aquilonius* but differs in having generally fewer midbody scale rows ( $\bar{x} = 30$  vs 32) than the type series and the dorsolateral margin variably patterned. The dorsal coloration of the majority of adult males from this population is uniformly mid to dark brown with numerous, fine, pale and dark flecks, only a few individuals having what could be interpreted as a pale dorsolateral margin.

Two adult male *Caledoniscincus* from Mt Ignambi approximately 20 km north of Mt Panié (NHMB 7325 collected by Roux and Sarasin in 1911 and a single recently collected specimen AMS R152223) are similar in colour and pattern to *C. aquilonius* from Mt Panié, but differ in being larger (52–55 mm SVL), having more dorsal scale rows (60), and coming from a much higher altitude (1,000 m vs maximum 690 m for *C. aquilonius* on Mt Panié). It is unclear whether these specimens represent another undescribed species or variation in both scalation and altitudinal limits not previously observed in *C. aquilonius*.

**Additional material.** The following specimens are also assigned to *C. aquilonius* but not included in the type series: AMS R77864, R77894, R144205, R144214–15, R144255–56, R146364–65, R149311–13, R149319–23, 149342–43, R149961–62, R149965, Mt Panié; CAS 182062, CAS 198713 Tao, 20°33'S 164°48'E; AMS R77809, R77812, R138513 R144249, R144252–53 Kavaatch Forestry Camp (abandoned), 20°42'S 164°50'E; AMS R144296–

97, R144259, R146338–341 Koumac Caves, approximately 9 km E of Koumac, 20°33'S 164°21'E; AMS R150706, R150709–20 39.6 km W of Hienghène on Ouyaguette road, 20.40'S 164.42'E; AMS R151346–47 vicinity of Ouinguip, 20°38'S 164°51'E; AMS R150672–83, R150691–92 47.2 km from Kone turnoff on road to east coast, 20°54'S 165°07'E.

***Caledoniscincus terma* n.sp.**

Figs. 5, 7

**Type material.** HOLOTYPE: AMS R146320 Mt Mandjélia, 10.3 km E Tade River crossing, New Caledonia, 20°24'S 164°30'E (R. Sadlier and A. Bauer, 4.iii.1995). PARATYPES: AMS R146312–14, R146316–19, R146321 same location as holotype; AMS R146344–46, MNHP 1997.3329 (formerly AMS R146315) Mt Mandjélia, 15 m asl below summit, 20°23'S 164°31'E 4/1/1995; MNHP 1997.3330 (formerly AMS R146348) Mt Mandjélia, 20°24'S 164°31'E.

**Etymology.** The species name is from the Latin *terma*, for end, alluding to the position of the type locality for this species at the northern end of the northeast ranges.

**Diagnosis.** *Caledoniscincus terma* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size 41–50 mm SVL; (b) tail relatively short, on average only 1.36

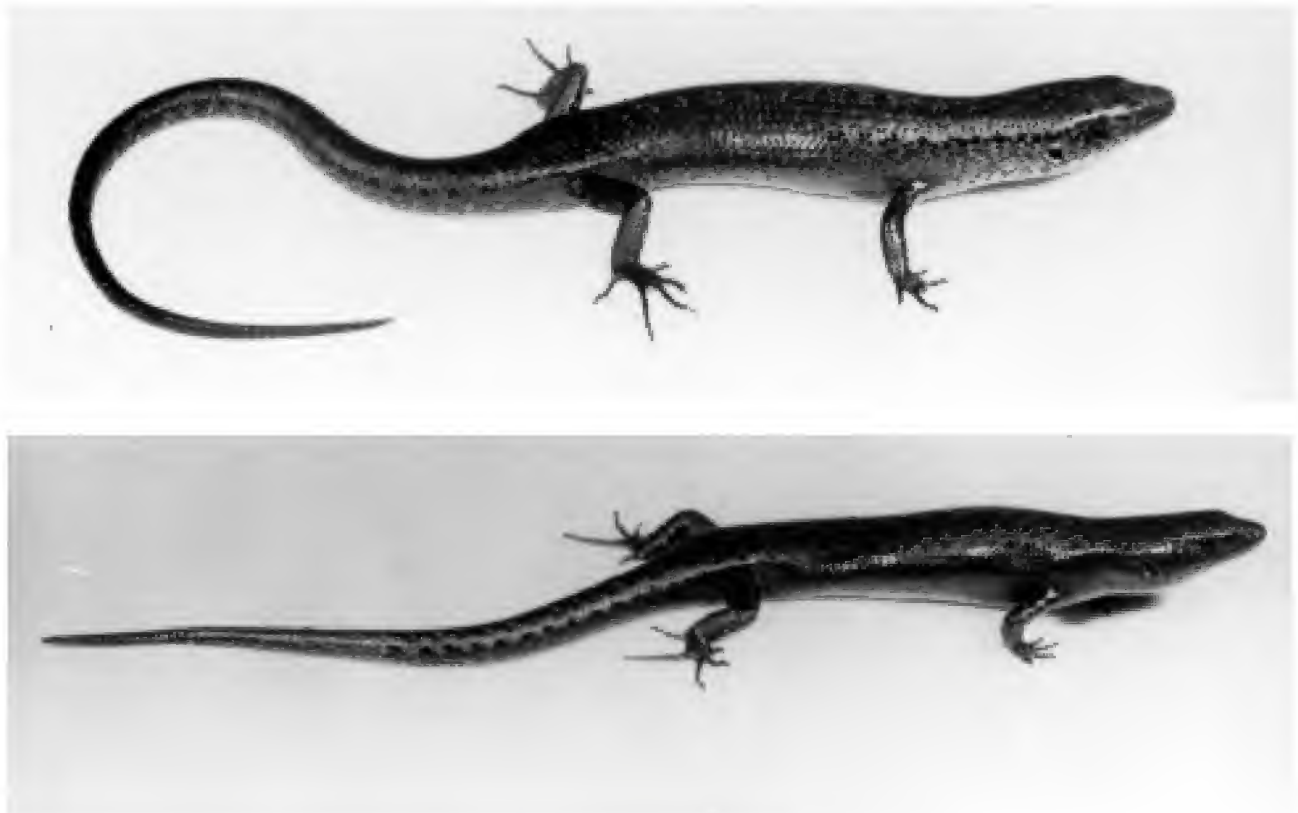
times longer than body; (c) midbody scales in 32–34 rows; (d) paravertebral scales in 55–63 rows; (e) postsacral vertebrae 37–38; (f) dorsal colour pattern of adult males featuring a pale vertebral stripe; lateral surface without a pale midlateral stripe; (g) rostral shield with a dark midrostral streak; (h) adult males with a yellow flush to the ventral surface in life.

**Description.** The description is based on a series of 14 specimens (4 males and 10 females) collected at the type location and includes specimens used in the electrophoresis study.

**Measurements.** Adult size 41–50 mm SVL; distance from axilla to groin 52.4–60.5% of SVL ( $\bar{x}$  = 56.3,  $n$  = 14); distance from forelimb to snout 34.1–40.1% of SVL ( $\bar{x}$  = 38.0,  $n$  = 14); hindlimb length 31.3–30.0% of SVL ( $\bar{x}$  = 35.1,  $n$  = 14); tail length 131.1–140.5% of SVL ( $\bar{x}$  = 135.8,  $n$  = 2).

**Scalation.** Midbody scales in 32–34 rows ( $\bar{x}$  = 32.4,  $SD$  = 0.85,  $n$  = 14); paravertebral scales in 55–63 rows ( $\bar{x}$  = 58.9,  $SD$  = 2.56,  $n$  = 14), no significant variation ( $P$  value  $\leq 0.05$ ) between males and females ( $\bar{x}$  = 57.3,  $n$  = 4 vs 59.6,  $n$  = 10,  $t_{12}$  = -1.655,  $P$  = 0.124); dorsal scales of fourth finger 9–10 ( $\bar{x}$  = 9.4,  $SD$  = 0.39,  $n$  = 14); lamellae of fourth finger 12–16 ( $\bar{x}$  = 14.4,  $SD$  = 1.16,  $n$  = 14); dorsal scales of fourth toe 13–15 ( $\bar{x}$  = 13.6,  $SD$  = 0.66,  $n$  = 14); lamellae of fourth toe 24–27 ( $\bar{x}$  = 25.4,  $SD$  = 0.99,  $n$  = 14).

**Osteology.** Presacral vertebrae 29–30 ( $\bar{x}$  = 29.1,  $SD$  = 0.26,  $n$  = 14); postsacral vertebrae 37–38 ( $\bar{x}$  = 37.5,  $SD$  = 0.70,  $n$  = 2).



**Figure 7.** *Caledoniscincus terma* male (upper) and female (lower) from Mt Mandjélia.



**Coloration.** Males: dorsal surface dark brown and with scattered, pale, dark-edged flecks; vertebral axis with a pattern of pale grey blotches forming a near continuous rough-edged stripe. Lateral surface dark brown (similar in colour to dorsal surface) and differentiated from dorsal surface anteriorly by a row of black flecks along laterodorsal edge; dorsal and lateral colorations tend to merge posterior to forelimb, dorsolateral edge rough and poorly defined. Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs yellow, continuing variably along underside of tail.

Females: dorsal surface mid brown with occasional light and numerous scattered darker flecks, larger individuals (>47 mm SVL) with a variably present series of poorly differentiated pale grey blotches along vertebral axis forming an obscure, but near continuous, rough-edged stripe down centre of back. Lateral surface dark brown-black, unmarked and with a well defined dorsolateral margin. Ventral surface from level of forelimbs to basal portion of tail and underside of fore and hindlimbs usually orange, occasionally yellow.

**Details of holotype.** Adult male; SVL 44 mm; distance from axilla to groin 24 mm; distance from forelimb to snout 18 mm; hindlimb length 17 mm; tail length 67 mm, tip reproduced.

Midbody scales rows 34; paravertebral scale rows 58; dorsal scales of fourth finger 9/10; lamellae of fourth finger 14/14; dorsal scales of fourth toe 15/15; lamellae of fourth toe 26/25.

Presacral vertebrae 29.

**Distribution.** Known only from Mt Mandjélia, the northern most peak on the northeast ranges of New Caledonia (Fig. 5).

**Biology.** Restricted to mid (500 m) to high (760 m) altitude closed forest.

Clutch size 2–3, gravid females collected during the summer wet season (January) contained oviducal eggs (1/2, n = 2, SVL 40–46 mm and 1/1, n = 2, SVL 43–45 mm).

**Additional material examined.** The following specimens are assigned to *C. terma* but not included in the type series: AMS R135738–43, R135749–59, Mandjélia, at and near the summit, 20°24'S 164°32'E.

### *Caledoniscincus renevieri* n.sp.

Figs. 5, 8

**Type material.** HOLOTYPE: AMS R146424 4.6 km N Col des Roussettes on Houailou-Bourail road, New Caledonia, 21°24'S 165°26'E (R. Sadlier and A. Bauer, 8.i.1997). PARATYPES: AMS R146392–95, R146423, R146425, R146427–29, CAS 198740–43, MNHP 19997.3333 (formerly AMS R146426), MNHP 1997.3334 (formerly AMS R146430) same data as holotype; AMS R135822 4.6 km N Col des Roussettes on Houailou-Bourail road, 21°24'S 165°26'E; AMS R77658–59, R77677 Mt Aoupinié (vicinity forestry camp 500 m), 21°09'S 165°20'E; AMS R146382–

84 Mt Aoupinié (1.5–2.5 km below forestry camp), 21°07'S 165°19'E; AMS R146499–501 Grottes des Adio, NE of Poya, 21°15'S 165°14'E.

**Etymology.** The species is named for Alain Renevier of Nouméa in recognition the generous hospitality and support he and his family have given during our field research in New Caledonia.

**Diagnosis.** *Caledoniscincus renevieri* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size 37–51 mm SVL; (b) tail approximately 1.4 times longer than body; (c) midbody scales in 30–32 rows; (d) paravertebral scales in 51–58 rows; (e) postsacral vertebrae 41–44; (f) adult male dorsal colour pattern transversely oriented, occasionally with pale vertebral markings; (g) lateral surface without a pale midlateral stripe; (h) rostral shield with a dark midrostral streak; (i) adult males with a yellow flush to the ventral surface in life.

**Description.** The description is based on a series of 23 specimens (12 males and 11 females) collected at the type locations and includes specimens used in the electrophoresis study.

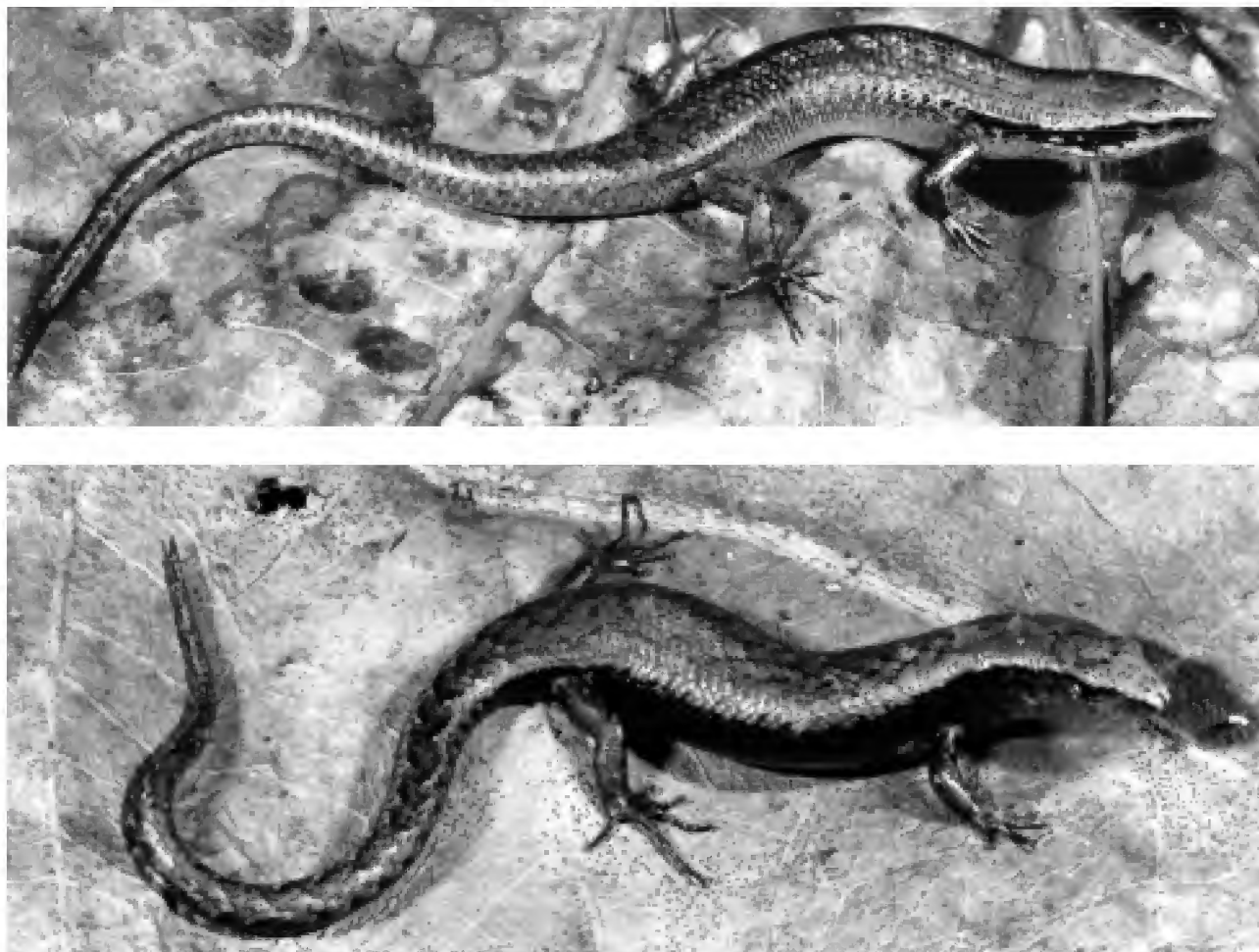
**Measurements.** Adult size 37–51 mm SVL; distance from axilla to groin 51.4–60.8% of SVL ( $\bar{x}$  = 55.4, n = 23); distance from forelimb to snout 33.3–42.9% of SVL ( $\bar{x}$  = 38.7, n = 23); hindlimb length 31.8–41.0% of SVL ( $\bar{x}$  = 36.6, n = 23); tail length 127.3–154.3% of SVL ( $\bar{x}$  = 140.2, n = 3).

**Scalation.** Midbody scales in 30–32 rows ( $\bar{x}$  = 30.3, SD = 0.69, n = 23); paravertebral scales in 51–58 rows ( $\bar{x}$  = 53.6, SD = 2.02, n = 23), significant variation (P value  $\leq 0.05$ ) between males and females ( $\bar{x}$  = 52.4, n = 12 vs 54.9, n = 11,  $t_{21}$  = -3.730, P = 0.001); dorsal scales of fourth finger 8–10 ( $\bar{x}$  = 9.0, SD = 0.49, n = 23); lamellae of fourth finger 13–16 ( $\bar{x}$  = 13.6, SD = 0.61, n = 23); dorsal scales of fourth toe 12–13 ( $\bar{x}$  = 12.7, SD = 0.47, n = 23); lamellae of fourth toe 21–29 ( $\bar{x}$  = 24.7, SD = 1.40, n = 23).

**Osteology.** Presacral vertebrae 29–30 ( $\bar{x}$  = 29.2, SD = 0.41, n = 20); postsacral vertebrae 41–44 ( $\bar{x}$  = 42.7, SD = 1.53, n = 3).

**Coloration.** Males: dorsal surface light to mid brown with numerous pale, dark-edged flecks, dark edging of pale markings tending to align obliquely to form narrow, dark bars; pale markings along vertebral axis tending to align to form a near continuous rough-edged stripe in some larger individuals. Lateral surface darker than dorsal, variably with light and dark flecks; side of head and neck dark brown to black uppermost. Dorsolateral margin defined anteriorly (between eye and forelimbs) by a pale, narrow (<1 scale width), dark-edged stripe, becoming obscure between fore and hindlimbs. Ventral surface moderate to pale yellow in life posterior of forelimbs, throat with an orange tinge.

Females: dorsal surface light-mid brown, variably with scattered dark flecks. Lateral surface darker than dorsal; mid to dark brown uppermost and unmarked; side of head and neck dark brown-black uppermost in larger individuals (>47 mm SVL). Dorsolateral margin defined anteriorly



**Figure 8.** *Caledoniscincus renevieri* male (upper) and female (lower) from Col des Roussettes.

(between eye and forelimbs) by a pale, narrow (<1 scale width) stripe, contrasting markedly with dark upperlateral colour between eye and forelimbs, and by the contrasting dark lateral and light upper lateral colour between fore and hindlimbs. Ventral surface either without obvious ventral colour (AMS R146394–95, R146425–26) or with a very faint yellow (AMS R146428 and R146430) or pink (AMS R146384) flush.

**Details of holotype.** Adult male; size 46 mm SVL; distance from axilla to groin 24 mm; distance from forelimb to snout 18 mm; hindlimb length 18 mm; tail length 71 mm, complete.

Midbody scale rows 30; paravertebral scale rows 53; dorsal scales of fourth finger 9/9; lamellae of fourth finger 14/14; dorsal scales of fourth toe 13/13; lamellae of fourth toe 23/24.

Presacral vertebrae 29; postsacral vertebrae 41.

**Distribution.** Known from three locations in the central ranges at Mt Aoupinié and Grottes des Adio (western foothills of Mt Aoupinié) in the north to Col des Roussettes in the south (Fig. 5). All locations are in relatively close

proximity to one another, the Adio and Mt Aoupinié locations are separated by 10 km, and these locations are approximately 25–30 km north of Col des Roussettes.

**Biology.** Lowland and mid-altitude closed forests where it can be relatively abundant. On Mt Aoupinié and at Col des Roussettes it was collected in closed forest gullies and at Adio Caves in closed forest at the base of limestone outcrops.

Clutch size 2–4 (mode 2), gravid females collected during the summer wet season (January) contained oviducal eggs (1/1, n = 5, SVL 41–47 mm; 1/2, n = 1, SVL 51 mm; and 2/2, n = 1, SVL 50 mm).

***Caledoniscincus auratus* n.sp.**

Figs. 5, 9, 10

**Type material.** HOLOTYPE: AMS R144298 Koumac Caves, approximately 9 km E of Koumac, New Caledonia, 20°33'S 164°21'E (R. Sadlier, 23–24.iv.1994). PARATYPES: AMS R144299–300, R144304, MNHN 1997.3335 (formerly





**Figure 9.** *Caledoniscincus auratus* male from Koumac Caves.

AMS R144302), MNHN 1997.3336 (formerly AMS R144303) location as for holotype; AMS R144381–82 location as for holotype.

**Etymology.** The species name is from the Latin *auratus*, for golden or ornamented with gold, and alludes to the prominent gold flecking on adult males of this species.

**Diagnosis.** *Caledoniscincus auratus* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) moderately small size 38–51 mm SVL; (b) tail on average 1.47 times longer than body; (c) midbody scales in 28 rows; (d) paravertebral scales

in 52–55 rows; (e) postsacral vertebrae 43–45; (f) adult male dorsal colour pattern transversely oriented and without a pale vertebral stripe; (g) lateral surface without a pale midlateral stripe; (h) rostral shield with a dark midrostral streak; (i) adult males with a yellow flush to the ventral surface in life.

**Description.** The description is based on specimens collected at the type locations and includes only those specimens used in the electrophoresis.

**Measurements.** Adult size 38–51 mm SVL; distance from axilla to groin 52.6–56.9% of SVL ( $\bar{x}$  = 55.0,  $n$  = 8); distance from forelimb to snout 37.3–41.0% of SVL ( $\bar{x}$  = 39.5,  $n$  =



**Figure 10.** Closed forest habitat at Koumac Caves, near type locality of *Caledoniscincus auratus*.

8); hindlimb length 31.4–39.5% of SVL ( $\bar{x}$  = 37.5,  $n$  = 8); tail length 141.0–151.3% of SVL ( $\bar{x}$  = 146.8,  $n$  = 4).

**Scalation.** Midbody scales in 28 rows ( $n$  = 8); paravertebral scales in 52–55 rows ( $\bar{x}$  = 53.6,  $SD$  = 1.06,  $n$  = 8); dorsal scales of fourth finger 9–11 ( $\bar{x}$  = 9.25,  $SD$  = 0.46,  $n$  = 8); lamellae of fourth finger 12–15 ( $\bar{x}$  = 13.75,  $SD$  = 0.87,  $n$  = 8); dorsal scales of fourth toe 13–14 ( $\bar{x}$  = 13.1,  $SD$  = 0.23,  $n$  = 8); lamellae of fourth toe 21–25 ( $\bar{x}$  = 22.9,  $SD$  = 1.35,  $n$  = 8).

**Osteology.** Presacral vertebrae 29–30 ( $\bar{x}$  = 29.2,  $SD$  = 0.41,  $n$  = 20); postsacral vertebrae 43–45 ( $\bar{x}$  = 44.0,  $SD$  = 0.82,  $n$  = 4).

**Coloration.** Adult males: dorsal surface mid brown with a pattern of numerous pale, dark-edged spots, aligned to form a pattern of irregular and merging transverse bars (dark edging muted in smaller males 38–41 mm SVL); head with a few fine dark spots anteriorly. Lateral surface much lighter than dorsal, cream with a brownish wash uppermost and dark markings over most the surface; dark lateral markings largest and boldest uppermost, particularly in region between forelimb and ear opening, becoming suffused approaching the venter; laterodorsal margin between forelimb and ear opening light brown and distinct from darker lateral and dorsal colours. Ventral surface pale, with a moderate to dull yellow flush from level of forelimbs to basal portion of tail in some larger males.

Females: dorsal surface mid brown with sparse dark flecking. Lateral surface dark brown to black, uniform in colour; laterodorsal margin between forelimb and ear opening light brown and distinct from darker lateral and dorsal colours. Ventral surface pale, variably with a dull pink flush posterior of forelimbs in more mature females.

**Details of holotype.** Adult male; SVL 51 mm; distance from axilla to groin 29 mm; distance from forelimb to snout 19 mm; hindlimb length 16 mm; tail length 57 mm, mostly regenerated.

Midbody scales rows 28; paravertebral scale rows 52; dorsal scales of fourth finger 9/9; lamellae of fourth finger 13/14; dorsal scales of fourth toe 13/13; lamellae of fourth toe 24/24.

Presacral vertebrae 29.

**Distribution.** Known only from Koumac Caves in the northwest of New Caledonia (Fig. 5).

**Biology.** Restricted to lowland closed forest (Fig. 10), resembling dry monsoon forest, adjacent to limestone outcrops at Koumac Caves.

**Additional material examined.** The following specimens are assigned to *C. auratus* but not included in the type series. They agree with the types in morphology but were not part of the electrophoretic analyses: AMS R144301, R146331, R146333, R144384 same location as holotype.

**Comments.** A single female (SVL 43 mm) not included in the type series and collected during the summer wet season (January) had 3 oviducal eggs (1/2).

### *Caledoniscincus chazeau* n.sp.

Figs. 5, 11–13

**Type material.** HOLOTYPE: AMS R138515 Koulnoué, Hienghène region, New Caledonia, 20°41'32"S 164°59'10"E (R. Sadlier and A. Bauer, 26.ii.1992). PARATYPES: MNHP 1997.3337 (formerly AMS R138516), CAS 182073–74 same location as holotype.

**Etymology.** The species is named for Jean Chazeau of the Laboratoire de Zoologie Appliquée at ORSTOM Nouméa, in recognition of his generous support and enthusiasm for our research on New Caledonian lizards.

**Diagnosis.** *Caledoniscincus chazeau* can be distinguished from the other species of *Caledoniscincus* by the following combination of characters: (a) small size 36–43 mm SVL; (b) tail approximately 1.36 times longer than body; (c) midbody scales in 28–30 rows; (d) paravertebral scales in 59–61 rows; (e) postsacral vertebrae 42; (f) adult dorsal colour pattern transversely oriented and without a pale vertebral stripe; (g) lateral surface without a pale midlateral stripe; (h) rostral shield with a dark midrostral streak.

**Description.** The description is based on four specimens collected at the holotype location and includes specimens used in the electrophoresis study.

**Measurements.** Adult size 36–43 mm SVL; distance from axilla to groin 52.8–55.8% of SVL ( $\bar{x}$  = 54.6,  $n$  = 4); distance from forelimb to snout 37.2–38.9% of SVL ( $\bar{x}$  = 37.9,  $n$  = 4); hindlimb length 33.3–37.5% of SVL ( $\bar{x}$  = 34.8,  $n$  = 4); tail length 136.1% of SVL ( $n$  = 1).



**Figure 11.** *Caledoniscincus chazeau* from Koulnoué, Hienghène region.

**Scalation.** Midbody scales in 28–30 rows ( $\bar{x}$  = 29.0,  $SD$  = 1.55,  $n$  = 4); paravertebral scales in 59–61 rows ( $\bar{x}$  = 59.8,  $SD$  = 0.96,  $n$  = 4); dorsal scales of fourth finger 9 ( $n$  = 4); lamellae of fourth finger 12–14 ( $\bar{x}$  = 13.4,  $SD$  = 0.95,  $n$  = 4); dorsal scales of fourth toe 12–13 ( $\bar{x}$  = 12.8,  $SD$  = 0.5,  $n$  = 4); lamellae of fourth toe 21–23 ( $\bar{x}$  = 22.3,  $SD$  = 0.50,  $n$  = 4).

**Osteology.** Presacral vertebrae 29 ( $n$  = 4); postsacral vertebrae 42 ( $n$  = 1).

**Coloration.** The following decryption of colour and pattern is based on two adult females (AMS R138515 and MNHP 1997.3337). Dorsal surface mid brown with a pattern of numerous pale spots, dark-edged at sides, aligned to form a pattern of irregular and merging transverse bars; head with a few fine dark spots anteriorly. Lateral surface between





**Figure 12.** Isolate limestone outcrops in Hienghène region, typical habitat for *Caledoniscincus chazeaui*.

fore and hindlimbs brown and unmarked, similar to and merging with dorsal surface but becoming lighter approaching venter; between forelimb and ear opening with light and dark markings and either side of eye with bold dark markings; laterodorsal margin between forelimb and ear marked by a narrow, pale, dark-edged stripe, distinct from darker lateral and dorsal colours. Ventral surface pale and unmarked; colour in life unknown.

**Details of holotype.** Adult female; size 42 mm SVL; distance from axilla to groin 23 mm; distance from forelimb to snout 16 mm; hindlimb length 14 mm; tail length 51 mm, reproduced.

Midbody scales rows 28; paravertebral scale rows 59; dorsal scales of fourth finger 9/9; lamellae of fourth finger 12/12; dorsal scales of fourth toe 12/12; lamellae of fourth toe 22/21.

Presacral vertebrae 29.

**Distribution.** The type specimens were collected from a single location at Koulnoué on the northeast coast in the vicinity of Hienghène (Fig. 5). Specimens from a disjunct forest patch approximately 10 km south of the type location possibly represent a second location for this species; however, they are only tentatively assigned to *Caledoniscincus chazeaui* pending further field research.

**Biology.** Restricted to lowland closed forest surrounding limestone outcrops south of Hienghène (Figs. 12, 13). The

forest patches are remnants and widely disjunct from one another, the intervening areas being covered with secondary growth or disturbed habitat, either through shifting cultivation, or regular burning to produce extensive areas of grassland.

**Additional material examined.** A series of 11 specimens (AMS R77823–29, R77832–35) collected 20 years ago from a nearby location (14 km south of the Hienghène River bridge, 20°43'27"S 165°02'00"E) are similar to specimens from the type locality in size, coloration, and habitat preferences. However, these specimens were not part of the electrophoresis study and showed significant differences in a number of scalation characters to the sample from the type locality. For these reasons they were not included in the type series of *Caledoniscincus chazeaui* and are here only tentatively assigned to this species.

Nine specimens from the sample collected 14 km south of the Hienghène River bridge showed the following counts for six variable scalation characters: midbody scales in 30–32 rows ( $\bar{x}$  = 30.4, SD = 0.88,  $n$  = 9); paravertebral scales in 60–64 rows ( $\bar{x}$  = 62.1, SD = 1.36,  $n$  = 9); dorsal scales of fourth finger 8–11 ( $\bar{x}$  = 8.9, SD = 0.93,  $n$  = 9); lamellae of fourth finger 13–16 ( $\bar{x}$  = 14.8, SD = 0.90,  $n$  = 9); dorsal scales of fourth toe 13–15 ( $\bar{x}$  = 13.9, SD = 0.76,  $n$  = 9); lamellae of fourth toe 23–32 ( $\bar{x}$  = 25.9, SD = 2.69,  $n$  = 8). For five of the six scalation characters this sample differs significantly from the type series in having: more midbody scales ( $\bar{x}$  = 30.4 vs 29,  $t_{11}$  = 2.494,  $P$  < 0.030); more dorsal



**Figure 13.** Closed forest growing on and around limestone outcrop in Hienghène region.

scales ( $\bar{x} = 62.1$  vs 59.8,  $t_{11} = 3.103$ ,  $P < 0.010$ ); more finger lamellae ( $\bar{x} = 14.8$  vs 13.4,  $t_{11} = 2.655$ ,  $P < 0.022$ ); more toe scales ( $\bar{x} = 13.9$  vs 12.8,  $t_{11} = 2.818$ ,  $P < 0.017$ ); and more toe lamellae ( $\bar{x} = 25.9$  vs 22.3,  $t_{10} = 2.654$ ,  $P < 0.024$ ).

Adult females from the series of specimens collected 14 km south of the Hienghène River bridge during the summer wet season (January) had yolked follicles (1/2,  $n = 1$ , SVL 41.5 mm) and oviducal eggs (1/2,  $n = 1$ , SVL 42.5 mm), indicating the clutch size of 3 for this population of *Caledoniscincus chazeaui*.

***Caledoniscincus cryptos* n.sp.**

Figs. 5, 14, 15

**Type material.** HOLOTYPE: AMS R135141 an adult male from 8.3 km from Kouaoua/Canala road intersection on La Foa road, New Caledonia, 21°34'S 165°49'E (R. Sadlier, 18/iii/1990).

**Etymology.** The species name is from the Greek *cryptos*, for hidden or concealed, and alludes to the recognition of this species through genetic analyses only.

**Diagnosis.** *Caledoniscincus cryptos* is recognised mainly on the following electrophoretic characteristics: (i) it is homozygous (in the only available specimen) for an allele

of *Gapdh(A)* which is found nowhere else in our samples; (ii) it is also homozygous for *Fbp(C)* and *G3pdh(A)* which are found only as single heterozygotes in non-sympatric *C. orestes* or *C. haplorhinus* respectively; (iii) it has fixed differences from morphologically similar *C. renevieri* and *C. auratus* at these three loci; (iv) additional fixed differences from *C. renevieri* are found at *Idhp-1* and *Pep:LA*; (v) an additional fixed difference from *C. auratus* is seen at *Pgdh*.

*Caledoniscincus cryptos* can also tentatively be distinguished from most other species of *Caledoniscincus* by the following combination of characters: (a) moderately small, 45 mm SVL; (b) midbody scales in 30 rows; (c) paravertebral scales in 51 rows; (d) adult male dorsal colour pattern transversely oriented and without a pale vertebral stripe; (e) lateral surface without a pale midlateral stripe; (f) rostral shield with a dark midrostral streak.

**Description and details of holotype.** *Measurements.* Size 45 mm SVL; distance from axilla to groin 24 mm (53.3% of SVL); distance from forelimb to snout 19 mm (42.2% of SVL); hindlimb length 18 mm (40.0% of SVL); tail missing.

*Scalation.* Midbody scales in 30 rows; paravertebral scales 51; dorsal scales of fourth finger 9/9; lamellae of fourth finger 12/13; dorsal scales of fourth toe 12/13; lamellae of fourth toe 25/25.

*Osteology.* Presacral vertebrae 29.

*Coloration.* Dorsal surface mid brown with a pattern of numerous pale spots, dark-edged at the sides, and aligned to form a reticulate pattern of irregular and merging dark transverse bars; head with a few fine dark spots anteriorly. Lateral surface brown and unmarked between fore and hindlimbs, similar to and merging with dorsal surface uppermost and becoming lighter approaching the venter; dark brown to black between forelimb and ear opening, dark markings boldest either side of eye between ear opening and snout; laterodorsal margin between forelimb and ear opening a narrow, pale, stripe distinct from darker lateral and dorsal colours.

Ventral surface pale, unmarked; colour in life unknown.

**Distribution.** Known only from a single site in the ranges near Col d'Amieu in the central ranges of New Caledonia (Fig. 5).

**Biology.** Known only from mid altitude closed forest (Fig. 15).

**Comparison of species**

**Electrophoretic results.** Fixed differences in sympatry support the recognition of the new taxa described here as distinct species from *Caledoniscincus austrocaledonicus* and *C. haplorhinus* where they occur at the same locality. There are three genetically distinct species found at Koumac (*C. aquilonius*, *C. auratus* and *C. haplorhinus*). There are a minimum of three fixed differences between any pair of these species at this site, indicating reproductive isolation. There are four fixed differences between *C. terma* and *C. austrocaledonicus* at Mandjélia (the rare IDHP-2 C



allozyme in the latter species not being found there). All three populations of *C. renevieri* occur in sympatry with *C. austrocaledonicus*, there are five fixed and two nearly fixed differences between the taxa at these localities. *Caledoniscincus chazeaui* has ten and *C. cryptos* eight fixed differences from sympatric *C. austrocaledonicus* in the single localities represented in the electrophoretic study.

Otherwise the species of *Caledoniscincus* described here are largely allopatric sibling species restricted to closed forest in the central and northern regions of the island. The genetic data for these species indicate that *C. renevieri* + *C. auratus* + *C. cryptos* form a discrete group. These species are similar in size, adult male coloration, and ventral colour in both sexes (*C. renevieri* + *C. auratus*), and as such may ultimately be recognised as a natural group. Conversely *C. aquilonius* + *C. terma* and *C. chazeaui* are part of a larger group that also includes *C. austrocaledonicus*, *C. haplorhinus*, and *C. orestes*. No unifying morphological trait that might be indicative of close relationship has been identified in the species in this group.



**Figure 14.** *Caledoniscincus cryptos* holotype (AMS R135141).

The genetic distance (0.12) separating morphospecies *Caledoniscincus aquilonius* and *C. terma* is relatively small. This is a low value for distances between species in the Scincidae (Kim *et al.*, 1978; Milton *et al.*, 1983; Murphy *et al.*, 1983; Daugherty *et al.*, 1990; Sadlier *et al.*, 1993). *Caledoniscincus aquilonius* and *C. terma* are, however, clearly distinct on a number of morphological characteristics, emphasising that genetic distance alone should not be used as a criterion of species level differentiation.

**Morphology.** Table 3 shows the range of variation for those mensural, scalation, and coloration characteristics used in the diagnoses in the species accounts, and provides a ready cross-comparison of these key features between all species of *Caledoniscincus*.

*Caledoniscincus austrocaledonicus* and *Caledoniscincus haplorhinus* are the two most widespread species dealt with here, they are sympatric at a number of locations on New Caledonia, its satellite islands, and the Loyalty Islands. In the south of the main island, Isle des Pins, and Loyalty Islands, *C. austrocaledonicus* lacks a white midlateral stripe, this will readily distinguish it from regionally sympatric *C.*

*haplorhinus*. In the northern and central regions of the main island *C. austrocaledonicus* and *C. haplorhinus* are similar in size, scalation, and certain aspects of coloration, most notably both have a pale midlateral stripe. Samples of either sex in these regions can be distinguished by the expression and positioning of the white midlateral stripe at the ear opening as outlined in the diagnosis of *C. austrocaledonicus*.

The six new species described, *Caledoniscincus aquilonius*, *C. terma*, *C. renevieri*, *C. auratus*, *C. cryptos*, and *C. chazeaui*, can be distinguished from the other species in the genus as follows:

*Caledoniscincus festivus* is larger in adult size, has more paravertebral scale rows (similar range for *C. chazeaui*), and more postsacral vertebrae. Adult male *C. festivus* can be further distinguished from adult male *C. aquilonius* by ventral colour (yellow vs orange).

*Caledoniscincus atropunctatus* lacks the dark midrostral streak present in all these species, and has more postsacral vertebrae. *Caledoniscincus atropunctatus* can be further distinguished from adult male *C. aquilonius* by ventral colour (yellow vs orange).

*Caledoniscincus orestes* is larger in adult size, has a pale vertebral stripe in adult males (present also in *C. terma* and some *C. renevieri*), and more postsacral vertebrae. Adult male *C. orestes* can be further distinguished from adult male



**Figure 15.** Typical closed forest habitat in gully near type locality of *Caledoniscincus cryptos*.

*C. terma*, *C. renevieri*, and *C. auratus* by ventral colour (orange vs yellow).

*Caledoniscincus austrocaledonicus* has a pale vertebral stripe in adult males (present also in *C. terma* and some *C. renevieri*). Adult male *C. austrocaledonicus* are further distinguished from adult male *C. terma*, *C. renevieri*, and *C. auratus* by ventral colour (orange vs yellow). *Caledoniscincus austrocaledonicus* (northern and central populations) can also be further distinguished by the presence of a pale midlateral stripe in both sexes.

*Caledoniscincus haplorhinus* has a pale vertebral stripe in adult males (present also in *C. terma* and some *C. renevieri*), a pale midlateral stripe in both sexes, and more postsacral vertebrae.

*Caledoniscincus aquilonius*, *C. terma*, *C. renevieri*, *C. auratus*, *C. cryptos*, and *C. chazeaui* are generally all most similar to one another in scalation, osteology, and to a lesser degree adult male coloration. Significant differences in morphology between these species (except *C. cryptos*) are given below as pairwise comparisons.

*Caledoniscincus aquilonius* can be distinguished from *C. terma* by: having fewer dorsal scale rows ( $\bar{x} = 55.8$  vs 58.9,  $t_{27} = -3.939$ ,  $P < 0.001$ ), a longer tail ( $\bar{x} = 154.6$  vs 135.8% SVL) and more postsacral vertebrae ( $\bar{x} = 43.5$  vs 37.5), lacking a pale vertebral stripe (adult *C. terma* have a pale vertebral stripe, most obvious in males), and adult male ventral colour (orange vs yellow).

*Caledoniscincus aquilonius* can be distinguished from *C. renevieri* by: having more midbody scale rows ( $\bar{x} = 32.2$  vs 30.3,  $t_{36} = 6.768$ ,  $P < 0.001$ ), more dorsal scale rows in males ( $\bar{x} = 55.3$  vs 52.4,  $t_{18} = 4.892$ ,  $P < 0.001$ ), more fourth finger lamellae ( $\bar{x} = 14.4$  vs 13.6,  $t_{36} = 3.975$ ,  $P < 0.001$ ), and adult male ventral colour (orange vs yellow).

*Caledoniscincus aquilonius* can be distinguished from *C. auratus* by: having more midbody scale rows ( $\bar{x} = 32.2$  vs 28.0), more fourth toe lamellae ( $\bar{x} = 25.2$  vs 22.9,  $t_{20} = 4.224$ ,  $P < 0.001$ ), and adult male ventral colour (orange vs yellow).

*Caledoniscincus aquilonius* can be distinguished from *C. chazeaui* by: having more midbody scale rows ( $\bar{x} = 32.2$  vs 29.0,  $t_{17} = 5.191$ ,  $P < 0.001$ ); fewer dorsal scale rows ( $\bar{x} = 55.8$  vs 59.8,  $t_{17} = -5.512$ ,  $P < 0.001$ ); and more fourth toe lamellae ( $\bar{x} = 25.2$  vs 22.3,  $t_{16} = 4.984$ ,  $P < 0.001$ ).

*Caledoniscincus terma* can be distinguished from *C. renevieri* by: having more midbody scale rows ( $\bar{x} = 32.3$  vs 30.4,  $t_{22} = 4.106$ ,  $P < 0.001$ ), more dorsal scale rows in both males ( $\bar{x} = 57.3$  vs 52.4,  $t_{14} = 6.183$ ,  $P < 0.001$ ) and females ( $\bar{x} = 59.6$  vs 54.9,  $t_{19} = 4.744$ ,  $P < 0.001$ ), a shorter tail ( $\bar{x} = 136.3$  vs 140.2% SVL) with fewer postsacral vertebrae ( $\bar{x} = 37.5$  vs 42.7), and to a lesser extent in adult male dorsal coloration (pale vertebral stripe present vs usually absent in *C. renevieri*).

*Caledoniscincus terma* can be distinguished from *C. auratus* by: having more midbody scale rows ( $\bar{x} = 32.4$  vs 28.0), more dorsal scale rows ( $\bar{x} = 58.9$  vs 53.6,  $t_{20} = 5.555$ ,  $P < 0.001$ ), more fourth toe lamellae ( $\bar{x} = 25.4$  vs 22.9,  $t_{20} = 4.841$ ,  $P < 0.001$ ), a shorter tail ( $\bar{x} = 136.3$  vs 146.8% SVL) with fewer postsacral vertebrae ( $\bar{x} = 37.5$  vs 44.0), and adult male dorsal coloration (pale vertebral stripe present vs absent in *C. auratus*).

*Caledoniscincus terma* can be distinguished from *C. chazeaui* by: having more midbody scale rows ( $\bar{x} = 32.4$  vs 29.0,  $t_{16} = 6.601$ ,  $P < 0.001$ ), more fourth toe lamellae ( $\bar{x} = 25.4$  vs 22.3,  $t_{16} = 5.974$ ,  $P < 0.001$ ), fewer postsacral vertebrae ( $\bar{x} = 37.5$  vs 42.0), and adult male dorsal coloration (pale vertebral stripe present vs absent in *C. chazeaui*).

*Caledoniscincus renevieri* can be distinguished from *C. auratus* by: having more midbody scale rows (30–32 vs 28), otherwise in scalation and adult male colour *C. renevieri* is most similar to *C. auratus* from Koumac.

*Caledoniscincus renevieri* can be distinguished from the type series of *C. chazeaui* by: having fewer dorsal scale rows ( $\bar{x} = 53.6$  vs 59.8,  $t_{25} = -5.902$ ,  $P < 0.001$ ).

*Caledoniscincus auratus* can be distinguished from *C. chazeaui* by: having fewer dorsal scale rows ( $\bar{x} = 53.6$  vs 59.8,  $t_{10} = -9.703$ ,  $P < 0.001$ ).

*Caledoniscincus cryptos* can be distinguished from adult male *C. aquilonius* by lacking a broad pale laterodorsal margin and from *C. terma* by lacking a pale vertebral stripe. *Caledoniscincus cryptos* is most similar in overall appearance to *C. renevieri* and *C. auratus* in having a reticulate patterned dorsal surface (except some *C. renevieri* which have pale vertebral markings). Although no meaningful comparison of scalation can be made between *C. cryptos* and either *C. renevieri* or *C. auratus*, the values for *C. cryptos* generally fall within a single standard deviation from the mean for all scalation characters of both species.

## Discussion

The results presented here have doubled the known number of species in the genus *Caledoniscincus* to 11. Relationships between the three isolated populations of *C. orestes* have yet to be investigated and may yield further cryptic species in the complex. Such a significant increase in diversity in the genus was unexpected on the basis of existing collections prior to 1990. Only a few of the taxa described here were represented in museum collections prior to this date, and then generally only as a small number of “anomalous” specimens in particular collections. The increase in species diversity has resulted from extensive field research over the past eight years that has targeted these “anomalous” specimens and the opportunity to collect in areas not previously investigated.

The results in this paper have several biogeographical implications. The distinction between northern and southern herpetofaunas previously identified (Bauer & Sadler, 1993) has predominantly been based on specific and generic endemism in the extensive ultramafic block that covers much of the southern third of the island. *Caledoniscincus* now shows extensive speciation north of the southern ultramafic block involving a complex of largely allopatric endemics. The presence of sister species of *Tropidoscincus* in the north (*T. variabilis*) and south (as defined by the extensive southern ultramafic block—*T. rohssii*) also reflect the distinction between northern and southern herpetofaunas, and is similar in distribution to the variation in coloration seen in the widespread species *C. austrocaledonicus*. The northeastern ranges have also been



identified as a significant area of endemism for lizards (Bauer & Sadlier, 1993). The description of *C. terma* from Mt Mandjélia increases the number of species endemic to this region to four (the scincid lizards *C. terma* and an undescribed *Nannoscincus*, and the gekkonid lizards *Bavayia ornata* and *Bavayia validiclavis*). The results of our research indicate that the distribution patterns of the forest-restricted species described in this paper may reflect finer scale biogeographic regions across the central and northern regions of the island than previous studies have indicated. Further studies on widespread lizard taxa are required to see if similar distribution patterns occur.

Despite extensive field research by the authors in New Caledonia over the past eight years most of the new taxa described here are still only known from a few locations. Further field research is required to delimit accurately the distributions of these species.

### Conservation status

The conservation status of the species described in this paper are assessed below and follows Bauer & Sadlier (1993) in utilising a combination of known sites to assess distribution, average number of records per site as an indication of relative abundance, and known threats to assess vulnerability. The species are then categorised as per the current IUCN (1996) criteria where appropriate.

*Caledoniscincus austrocaledonicus* and *C. haplorhinus* are widespread and common species, neither are considered threatened and are not discussed further.

Of the six closed forest dependent species described here *Caledoniscincus aquilonius* and *C. renevieri* are the least restricted in distribution. *Caledoniscincus aquilonius* is likely to be the most widespread of the six species described here. Aside from the type location at Mt Panié it is known from four scattered localities in the far northeast ranges from near sea level to 670 m altitude, and in this region is likely to occur where suitable closed forest habitat is present. Populations of *C. aquilonius* in this region are relatively secure although lowland populations are likely to be threatened by loss of habitat as a result of clearing for agriculture and the impact of fire on forest margins. Extralimital populations of *Caledoniscincus aquilonius* are known from Koumac Caves on the west coast and the ranges west of Poindimié. The conservation status of these extralimital populations is difficult to assess until more data on the species distribution are available, particularly in the south and far north of the species range. The population of *C. aquilonius* from Koumac Caves is considered the most vulnerable. It is known only from the seasonally dry closed forests at Koumac Caves where remnant closed forest at the edge of the limestone outcrops is threatened by clearing for agriculture, degradation to the forest understorey and litter layer by stray cattle from adjacent farms, and fire. Because of its isolated nature and the threats posed by human activities the Koumac population of *C. aquilonius* could be regarded as potentially endangered. Research to determine the distinctiveness of this population is required before its conservation significance can be assessed under the current IUCN (1996) classification system.

*Caledoniscincus renevieri* is known from three sites in general proximity to one another in the central ranges from low to mid altitude, and in this region is likely to occur where there is suitable closed forest habitat. Populations of *C. renevieri* in this region are relatively secure although, like *C. aquilonius*, lowland populations are likely to be threatened by loss of habitat due to clearing for agriculture and fire burning the forest margins. The impact of such activities is most clearly seen at Adio Caves where closed forest habitat has been cleared to the edge of the outcropping limestone.

It is likely that with further field research both *C. aquilonius* and *C. renevieri* will become known from more localities, and both species will prove to be both moderately widespread and secure within the discrete regions in which they occur.

Two species, *Caledoniscincus auratus* and *C. chazeaui* are very restricted in distribution. Both are known to be, or have been, generally common where they occur, but are likely to be adversely affected by habitat disturbance.

*Caledoniscincus auratus* is known with certainty only from the seasonally dry closed forests at Koumac Caves. At this locality, closed forest at the edge of the limestone outcrops is threatened by clearing for agriculture, degradation to the forest understorey and litter layer by stray cattle from adjacent farms, and fire. Situated on the lowlands of the west coast, this forest is seasonally dry and is likely to be particularly vulnerable to the impact of fires which could alter the canopy and modify the structural and microclimate characteristics, in turn possibly adversely affecting the population of *C. auratus*. Recently a sample of three specimens containing two adult males similar in coloration to adult males from the type series of *C. auratus* was collected from near Kaala-Gomen, approximately 20 km south of Koumac. These specimens also were from closed forest habitat in the vicinity of limestone outcrops, and it is possible they represent the occurrence of a second population of this species in the region. Because of its apparently restricted distribution i.e. known with certainty from only a single isolated location, but possibly present at a second nearby location, *C. auratus* should at the very least be regarded as Vulnerable:D2 under the current IUCN (1996) classification system (area of occupancy <100 km<sup>2</sup> or number of locations <5). When the threats posed by human activities at the type locality are also taken into account *C. auratus* could potentially be assessed as Endangered:B1/2c (extent of occurrence <100 km<sup>2</sup>; known to exist at one, possibly two, locations; continuing decline in area, extent and/or quality of habitat). However, the extent of the species distribution in the region needs to be determined, and the extent of decline in both area and quality of habitat to known sites needs to be established.

*Caledoniscincus chazeaui* is similarly restricted in distribution and habitat preference. It is known with certainty only from remnant closed forest at the edge of near-coastal limestone outcrops at Koulnoué, south of Hienghène in the northeast of the island. It was collected in 1992 in an area of closed forest habitat adjacent to limestone outcrops that bordered local gardens. Since that time the area has been revisited on two occasions (1994 and 1995)



and *C. chazeaui* was not observed either time. These years were atypically dry and it is possible the local distribution of *C. chazeaui* may fluctuate with seasonal change, to be restricted to more mesic sites under suboptimal conditions. Whatever the reason for its apparent absence from this site during these latter visits, it suggests this species might be sensitive to climatic or human alteration to the habitat. Other areas of closed forest surrounding other outcrops in the region south of Hienghène are similarly developed. Samples from a nearby site tentatively assigned to this species were collected in 1978. This site was visited again in 1992 and appeared to have changed markedly in the intervening 13 years from being uninhabited to now settled with intensive subsistence agriculture carried out to the margin of the closed forest at the base of the limestone outcrops. Because of the isolated nature of the known populations and the threats posed by human activities, *C. chazeaui* could be regarded as Endangered:B1/2c under the current IUCN (1996) classification system (extent of occurrence <100 km<sup>2</sup>; one, possibly two, isolated subpopulations with a reduced probability of recolonization, if once extinct; continuing decline in area, extent and/or quality of habitat).

*Caledoniscincus terma* is very restricted in distribution but common where it occurs. It is not considered under any immediate threat, but because of its restricted distribution the population could be regarded as Vulnerable:D2 under the current IUCN (1996) classification system (area of occupancy <100 km<sup>2</sup> or number of locations <5).

*Caledoniscincus cryptos* is known only from a single specimen. Field research in the general area where *C. cryptos* was collected is likely to show it to be more widespread in distribution, though its apparent rarity and absence from other sites collected in the vicinity of Col d'Amieu is perplexing. For these reasons it regarded as Data Deficient under the current IUCN (1996) classification system.

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**Table 1.** Allozymic frequencies in *Caledoniscincus* populations. The enzyme name, abbreviation and E.C. number are given in the first row of data for each locus. Numbers in the next row indicate sample sizes. Population listings loosely follow a North to South and West to East order. *Caledoniscincus aquilonius* 1 is from Koumac, *C. aquilonius* 2 from Mt Panié and *C. aquilonius* 3 from Kavaatch. *Caledoniscincus renevieri* 1 is from Mt Aoupinié, *C. renevieri* 2 from Adio Caves and *C. renevieri* 3 from Col des Roussettes. Species' names abbreviated to first five letters.

locus	<i>aquil.</i> 1	<i>aquil.</i> 2	<i>aquil.</i> 3	<i>terma.</i>	<i>aurat.</i>	<i>renev.</i> 1	<i>renev.</i> 2	<i>renev.</i> 3	<i>crypt.</i>	<i>chaze.</i>	<i>orest.</i>	<i>haplo.</i>	<i>austr.</i>
<b>AAT1 aspartate aminotransferase 2.6.1.1</b>													
(n)	8	6	5	7	2	3	4	6	1	4	5	23	77
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	—	1.000	1.000	—
B	—	—	—	—	—	—	—	—	—	—	—	—	1.000
C	—	—	—	—	—	—	—	—	—	1.000	—	—	—
<b>AAT2 aspartate aminotransferase 2.6.1.1</b>													
(n)	8	6	6	7	2	3	4	6	1	4	5	23	79
A	—	—	—	—	—	—	—	—	—	—	—	—	—
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
<b>FBP fructose biphosphatase 3.1.3.11</b>													
(n)	7	6	6	6	2	2	3	5	1	4	5	23	78
A	0.071	—	0.083	—	0.250	—	—	—	—	—	—	0.087	0.019
B	0.929	1.000	0.917	1.000	0.750	1.000	1.000	1.000	—	1.000	—	0.913	0.981
C	—	—	—	—	—	—	—	—	1.000	—	0.100	—	—
D	—	—	—	—	—	—	—	—	—	—	0.900	—	—
<b>FH1 fumarate hydratase 4.2.1.2</b>													
(n)	7	6	6	5	2	3	2	5	1	4	5	22	72
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.951
B	—	—	—	—	—	—	—	—	—	—	—	—	0.049
<b>FH2 fumarate hydratase 4.2.1.2</b>													
(n)	8	6	6	7	9	3	4	6	1	4	5	22	73
A	—	—	—	—	0.056	—	—	—	—	—	—	—	0.014
B	—	—	—	—	0.944	1.000	1.000	1.000	1.000	—	—	—	0.288
C	1.000	1.000	1.000	1.000	—	—	—	—	—	1.000	—	1.000	0.699
D	—	—	—	—	—	—	—	—	—	—	1.000	—	—
<b>GAPDH glyceraldehyde-3-phosphate dehydrogenase 1.2.1.12</b>													
(n)	8	6	6	7	9	3	3	6	1	4	5	23	74
A	—	—	—	—	—	—	—	—	1.000	—	—	—	—
B	—	—	—	—	—	—	—	—	—	—	—	—	0.061
C	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	—	1.000	1.000	1.000	0.770
D	—	—	—	—	—	—	—	—	—	—	—	—	0.169
<b>G3PDH glycerol-3-phosphate dehydrogenase 1.1.1.8</b>													
(n)	4	1	2	5	1	3	4	5	1	2	3	21	62
A	—	—	—	—	—	—	—	—	1.000	—	—	—	0.008
B	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	—	1.000	1.000	—	0.992
C	—	—	—	—	—	—	—	—	—	—	—	1.000	—
<b>GPI glucosephosphate isomerase 5.3.1.9</b>													
(n)	8	6	6	7	9	3	3	6	1	4	5	21	77
A	0.625	1.000	0.167	1.000	0.889	1.000	1.000	1.000	0.500	1.000	1.000	1.000	1.000
B	—	—	—	—	0.111	—	—	—	0.500	—	—	—	—
C	0.375	—	0.833	—	—	—	—	—	—	—	—	—	—
<b>IDHP-1 isocitrate dehydrogenase (NADP<sup>+</sup>) 1.1.1.42</b>													
(n)	8	6	6	7	9	3	4	6	1	4	5	23	78
A	—	—	—	—	—	—	—	—	—	—	—	1.000	—
B	—	—	—	—	—	1.000	1.000	1.000	—	—	—	—	—
C	—	—	—	—	—	—	—	—	—	—	1.000	—	1.000
D	—	—	—	—	1.000	—	—	—	1.000	—	—	—	—
E	—	—	—	—	—	—	—	—	—	—	—	—	—
null	1.000	1.000	1.000	1.000	—	—	—	—	—	1.000	—	—	—
<b>IDHP-2 isocitrate dehydrogenase (NADP<sup>+</sup>) 1.1.1.42</b>													
(n)	8	6	6	7	9	3	4	6	1	4	5	23	78
A	—	—	—	—	—	—	—	—	—	—	—	1.000	—
B	1.000	1.000	0.917	—	0.111	1.000	1.000	1.000	1.000	1.000	—	—	—
C	—	—	—	0.357	—	—	—	—	—	—	—	—	—
D	—	—	0.083	—	0.889	—	—	—	—	—	—	—	0.994
E	—	—	—	0.643	—	—	—	—	—	—	—	—	0.006
F	—	—	—	—	—	—	—	—	—	—	1.000	—	—

Table 1. Continued ...

	<i>aquil.</i>	<i>aquil.</i>	<i>aquil.</i>	<i>terma.</i>	<i>aurat.</i>	<i>renev.</i>	<i>renev.</i>	<i>renev.</i>	<i>crypt.</i>	<i>chaze.</i>	<i>orest.</i>	<i>haplo.</i>	<i>austr.</i>
locus	1	2	3			1	2	3					
<b>LDH-1</b>	<b>L-lactate dehydrogenase 1.1.1.27</b>												
(n)	8	5	6	7	8	3	4	6	1	4	1	23	79
A	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
B	—	—	—	—	0.250	—	—	—	—	—	—	—	—
<b>LDH-2</b>	<b>L-lactate dehydrogenase 1.1.1.27</b>												
(n)	8	5	6	7	9	3	4	6	1	4	5	22	77
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
<b>MDH-1</b>	<b>malate dehydrogenase 1.1.1.37</b>												
(n)	8	6	6	4	9	3	4	6	1	4	5	23	77
A	—	—	—	—	1.000	1.000	1.000	1.000	1.000	1.000	—	—	—
B	1.000	1.000	1.000	1.000	—	—	—	—	—	—	1.000	1.000	1.000
<b>MDH-2</b>	<b>malate dehydrogenase 1.1.1.37</b>												
(n)	8	6	6	7	9	3	4	6	1	4	5	23	79
A	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
<b>MPI</b>	<b>mannose-6-phosphate isomerase 5.3.1.8</b>												
(n)	8	6	6	7	2	3	3	6	1	4	5	22	78
A	—	—	—	0.071	—	—	—	—	—	—	—	0.409	0.019
B	1.000	1.000	1.000	0.929	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.591	0.974
C	—	—	—	—	—	—	—	—	—	—	—	0.006	—
<b>PEP:LA</b>	<b>peptidase leucine-alanine substrate 3.4.13.-</b>												
(n)	6	6	6	2	2	2	2	3	1	4	5	16	64
A	—	—	—	—	—	—	—	—	—	—	—	—	0.016
B	—	—	—	—	—	0.500	1.000	—	—	1.000	—	0.250	0.070
C	1.000	1.000	1.000	1.000	—	0.500	—	1.000	—	—	1.000	0.750	0.914
D	—	—	—	—	1.000	—	—	—	1.000	—	—	—	—
<b>PEP:LGG</b>	<b>peptidase leucine-glycine-glycine substrate 3.4.13.-</b>												
(n)	7	6	6	7	2	3	4	6	1	4	1	22	75
A	—	—	0.083	—	1.000	—	—	—	—	1.000	—	0.045	0.033
B	0.929	0.750	0.750	0.857	—	1.000	1.000	0.167	—	—	1.000	0.955	0.933
C	0.071	0.250	0.167	0.143	—	—	—	0.833	0.500	—	—	—	0.033
D	—	—	—	—	—	—	—	—	0.500	—	—	—	—
<b>PEP:PP</b>	<b>peptidase phenylalanine-proline substrate 3.4.13.-</b>												
(n)	8	5	6	7	2	3	4	6	1	4	5	23	76
A	—	—	0.167	0.214	1.000	1.000	1.000	1.000	1.000	—	1.000	0.022	0.039
B	1.000	1.000	0.833	0.786	—	—	—	—	—	1.000	—	0.978	0.961
<b>PGDH</b>	<b>phosphogluconate dehydrogenase 1.1.1.44</b>												
(n)	8	5	6	7	9	3	4	6	1	4	5	23	77
A	—	—	—	—	—	—	—	—	—	—	—	—	0.006
B	—	—	—	—	—	—	—	—	—	—	—	—	0.013
C	—	—	—	—	—	—	—	—	—	—	—	—	0.006
D	—	—	—	—	—	1.000	1.000	1.000	1.000	—	—	0.065	0.065
E	—	—	—	1.000	1.000	—	—	—	—	1.000	—	—	—
F	1.000	1.000	0.917	—	—	—	—	—	—	—	0.800	0.891	0.909
G	—	—	0.083	—	—	—	—	—	—	—	0.200	—	—
H	—	—	—	—	—	—	—	—	—	—	—	0.043	—
<b>PGM</b>	<b>phosphoglucomutase 5.4.2.2</b>												
(n)	8	6	6	7	9	3	4	6	1	4	5	23	79
A	—	—	—	—	—	—	0.250	—	—	—	—	—	—
B	1.000	1.000	1.000	0.929	1.000	1.000	0.750	1.000	1.000	1.000	—	—	—
C	—	—	—	0.071	—	—	—	—	—	—	1.000	0.957	0.222
D	—	—	—	—	—	—	—	—	—	—	—	0.043	0.778



**Table 2.** Matrix of genetic distances between *Caledoniscincus* populations. The figures below the diagonal are Nei (1978) unbiased genetic distances and those above the diagonal are the percentage of fixed differences. Population identifications are the same as for Table 1. *Idhp-1* nulls are not included in fixed difference calculations; *austro.* = *austrocaledonicus*.

population:	1	2	3	4	5	6	7	8	9	10	11	12	13
1 <i>C. aquilonius</i> 1		0	0	15	30	20	25	20	40	20	30	20	15
2 <i>C. aquilonius</i> 2	0.007		0	15	30	20	25	20	40	20	30	20	15
3 <i>C. aquilonius</i> 3	0.010	0.035		15	20	15	20	15	35	15	25	20	10
4 <i>C. terma</i>	0.106	0.097	0.128		25	20	25	20	40	20	25	25	15
5 <i>C. auratus</i>	0.529	0.506	0.518	0.400		20	20	20	25	25	40	35	25
6 <i>C. renevieri</i> 1	0.321	0.312	0.342	0.345	0.271		0	0	25	35	30	30	15
7 <i>C. renevieri</i> 2	0.382	0.372	0.406	0.407	0.295	0.010		5	30	35	35	30	15
8 <i>C. renevieri</i> 3	0.346	0.315	0.350	0.361	0.281	0.044	0.092		20	35	30	30	15
9 <i>C. cryptos</i>	0.715	0.695	0.705	0.777	0.345	0.350	0.375	0.329		45	45	50	30
10 <i>C. chazeau</i>	0.298	0.277	0.322	0.275	0.356	0.376	0.364	0.423	0.719		45	30	20
11 <i>C. orestes</i>	0.370	0.365	0.389	0.375	0.580	0.439	0.486	0.475	0.804	0.784		25	20
12 <i>C. austro.</i>	0.258	0.250	0.300	0.289	0.723	0.539	0.568	0.599	0.961	0.580	0.380		20
13 <i>C. haplorhinus</i>	0.246	0.237	0.281	0.285	0.577	0.488	0.531	0.526	0.997	0.509	0.327	0.305	

**Table 3.** Distribution of key diagnostic characters for all species of *Caledoniscincus*; *austro. s* = southern population (Noumea), *austro. n* = northern and central populations (Mt Aoupinié), species' names abbreviated to first five letters.

	SIZE (SVL) range	TL (% SVL) range		DSR range		MBR range		post- sacral range		vertebral stripe	mid- lateral stripe	dark midrostral streak	adult male ventral colour
<i>aquil.</i>	39–49	146–163	155	54–58	55.8	30–34	32.2	40–44	43.5	no	no	yes	orange
<i>terma.</i>	41–50	131–140	136	55–63	58.9	32–34	32.4	37–38	37.5	yes	no	yes	yellow
<i>renev.</i>	37–51	127–154	140	51–58	53.6	30–32	30.3	41–44	42.7	+/-	no	yes	yellow
<i>aurat.</i>	38–51	141–151	147	52–55	53.6	28	–	43–45	44.0	no	no	yes	yellow
<i>chaze.</i>	36–43		136	59–61	59.8	28–30	29.0		42	no	no	yes	?
<i>crypt.</i>	45	–	–		51		30	–	–	no	no	yes	?
<i>orest.</i>	47–63	–	–	55–63	57.9	32–36	32.8		50	yes	no	yes	orange
<i>austro. s</i>	39–46	–	155	56–62	59.9	28–30	29.5	–	>46	yes	no	yes	orange
<i>austro. n</i>	44–57	–	≈150	58–65	61.2	30–32	31.2	–	>50	yes	yes	yes	orange
<i>haplo.</i>	42–55	156–174	165	59–67	63.0	28–32	30.0	51–55	52.3	yes	yes	yes	yellow
<i>festi.</i>	59–72	131–160	150	60–66	61.9	32–34	32.9	49–56	52.1	no	no	yes	yellow
<i>atrop.</i>	38–53	142–153	150	51–60	55.9	28–32	29.6	49–51	50	no	no	no	?yellow

\* corrections to Table 3 are printed on this replacement page (15 September 1999).

## Appendix 1

Registration numbers and corresponding tissue numbers (in brackets) for the specimens of *Caledoniscincus* used in the electrophoretic study. For each species a generalised place name for each population sampled is given, and listed in a north to south order.

### *Caledoniscincus atropunctatus*

Col d'Amieu R144282 (2342), R144383 (2303), R144174 (2541), R144175 (2542)  
Koumac R144295 (2596)

### *Caledoniscincus festivus*

Mt Koghis R135125 (0176)  
Col d'Amieu R144182 (2488)

### *Caledoniscincus orestes*

Mt Panié R144217 (2304), R144221 (2482), R144222 (2483), R144223 (2484), R144224 (2485)

### *Caledoniscincus austrocaledonicus*

Mandjélia R146322 (2830), R146323 (2831), R146324 (2832), R146325 (2833)  
Ouaïème R144239 (2293), R144240 (2294), R144243 (2550), R144244 (2551), R144245 (2552), R144246 (2553)  
Koulnoué R138326 (0817), R138327 (0818)  
Poindimié R144270 (2563), R144271 (2564), R144265 (2588), R144266 (2589), R144267 (2590), R144268 (2591)  
Mt Aoupinié R146386 (2887), CAS 198720 (2888), CAS 198725 (2885), CAS 198726 (2886), R146379 (3001), R146380 (3002)  
Adio Caves R146503 (3030), R146504 (3031)  
Poya CAS 198672 (2820), R146307 (3070), R146308 (3071), R146309 (3072)  
Col des Roussettes R146398 (2906), R146432 (2944)  
Col d'Amieu R144163 (2308), R144164 (2309), R144165 (2310), R144166 (2543), R144167 (2544), R144168 (2545)  
Sarraméa R144112 (2315), R144113 (2316), R144114 (2546), R144115 (2547), R144116 (2548), R144117 (2549)  
Plateau de Dogny R144137 (2284), R144138 (2285), R144284 (2489), R144285 (2490), R144286 (2491), R144287 (2492)  
Mt Do CAS 198674 (2922)  
Tomo R146294 (2810), R146295 (2811), R146296 (2812), R146297 (2813)  
Nouméa R135114 (0165), R135115 (0166), R135116 (0167), R135117 (0168), R135118 (0169)  
Mt Koghis R135126 (0177), R135127 (0178)  
Rivière Bleue R135133 (0182), R135134 (0183), R135135 (0184), R135136 (0185)  
Ile des Pins R138559 (0804), R138560 (0805), R138561 (0845), R138646 (0846)

### *Caledoniscincus haplorhinus*

Koumac R144284 (2289), R144285 (2290), R144257 (2538), R144258 (2539), R144288 (2593), R144289 (2594)  
Tomo R146301 (2816), R146302 (2817), CAS 198669 (2818), CAS 198670 (2819)  
Plage de Pindaï R146461 (2993), R146462 (2994), R146463 (2995), R146464 (2996)  
Plage de Ouano R146436 (2946), CAS 198763 (2947), R146437 (2948), CAS 198764 (2594)  
Nouméa R135119 (0170), R135120 (0171), R135121 (0172), R135122 (0173), R135123 (0174)

### *Caledoniscincus aquilonius*

Kavaatch R144249 (2555), R144252 (2296), R144250 (2556), R144251 (2557), R144253 (2297), CAS 182062 (0830)  
Mt Panié R144199 (2322), R144206 (2529), R144227 (2480), R144200 (2323), R144207 (2530), R144228 (2481)  
Koumac R144296 (2298), R144297 (2299), R144259 (2540), R144380 (2597), R146338 (2839), R146339 (2840), R146340 (2841), R146341 (2842)

### *Caledoniscincus terma*

Mt Mandjélia R146316 (2827), CAS 198680 (2828), R146346 (2844), R146344 (3003), R146345 (3004), R146320 (3005), R146321 (3006)

### *Caledoniscincus renevieri*

Mt Aoupinié R146382 (2932), R146383 (2933), R146384 (2934)  
Adio Caves R146499 (3026), R146500 (3027), R146501 (3028), AMB 4466 (3029)  
Col des Roussettes R146392 (2895), R146393 (2896), R146394 (2897), R146395 (2898), CAS 198745 (2938), R146423 (3008)

### *Caledoniscincus chazeaui*

Koulnoué CAS 182073 (0819), CAS 182074 (0820), R138515 (0821), R138516 (0822)

### *Caledoniscincus auratus*

Koumac R144298 (2300), R144299 (2301), R144300 (2302), R144301 (2476), R144302 (2477), R144303 (2478), R144304 (2479), R144381 (2598), R144382 (2599)

### *Caledoniscincus cryptos*

Col d'Amieu R135141 (0188)

# **The Scincid Lizard Genus *Sigaloseps* (Reptilia: Scincidae) from New Caledonia in the Southwest Pacific: Description of a New Species and Review of the Biology, Distribution and Morphology of *Sigaloseps deplanchei* (Bavay)**

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**ABSTRACT.** *Sigaloseps* is a genus of two species of scincid lizards endemic to the southern ultramafic region of New Caledonia in the southwest Pacific. The morphology, distribution, and habits of the moderately widespread species *Sigaloseps deplanchei* are reviewed. The other species in the genus represents a new taxon known only from two high altitude sites above 1,000 m asl. The conservation status of both species is assessed. *Sigaloseps deplanchei* is not regarded as threatened. The new species, *Sigaloseps ruficauda*, by virtue of its restricted distribution and habitat preference, is likely to be adversely affected by habitat modification, and is regarded as vulnerable.

SADLIER, ROSS A., & AARON M. BAUER, 1999. The scincid lizard genus *Sigaloseps* (Reptilia: Scincidae) from New Caledonia in the southwest Pacific: description of a new species and review of the biology, distribution and morphology of *Sigaloseps deplanchei* (Bavay). *Records of the Australian Museum* 51(1): 83–91.

The generic name *Sigaloseps* was originally proposed by Sadlier (1986) to include the small New Caledonian scincid lizard *Lygosoma deplanchei* Bavay (1869). At that time it was regarded as a monotypic genus and known only from a few specimens from a few localities in the south of New Caledonia.

Field research in the intervening decade has greatly increased both the amount of material available and our knowledge of the distribution and habits of *Sigaloseps deplanchei*. These data indicate that *S. deplanchei* is endemic to moist, closed forest in the ultramafic block in

the southern third of the island. It is relatively common in this habitat type and not considered to be under any immediate threat. Investigation of high altitude habitats in 1995 resulted in the discovery of a second species of *Sigaloseps* in southern New Caledonia. This species is so far known only from two sites in geographical proximity to one another, Mt Mou and Mt Ouin. The new *Sigaloseps* is one of only two species of skink known to be restricted to high altitude habitat in southern New Caledonia (the other being an undescribed species of *Marmorosphax*) and is likely to occur only as scattered relictual populations in



suitably moist habitats around 1,000 m in altitude. Because of its apparently restricted distribution and habitat preferences this new species of *Sigaloseps* is considered vulnerable.

In this paper we provide an overview of the biology and morphology of *Sigaloseps deplanchei* and describe the new species.

### Materials and methods

Acronyms. Specimen abbreviations are prefixed as follows: Australian Museum (AMS); California Academy of Sciences (CAS); Museum National d'Histoire Naturelle Paris (MNHN), Naturhistorisches Museum, Basel (NHMB); Auckland Museum (AIM).

Measurements. The following measurements were made for each adult specimen, as determined by reproductive maturity and/or obvious size classes, where possible: snout to vent length—measured from tip of snout to caudal edge of anal scales; axilla to groin distance—measured from middle of base of forelimb to middle of base of hindlimb; forelimb to snout length—measured from tip of snout to middle of base of forelimb; hindlimb length—measured from middle of base of hindlimb to tip of fourth toe including nail; tail length—measured from caudal edge of anal scales to tip of tail, on complete original tails only. Body measurements are expressed as percentages of snout to vent length (SVL) in the taxon accounts.

Scalation. Head scalation terminology generally follows Taylor (1935) as described and figured by Sadlier (1986), abbreviations in brackets are those used in Table 1; midbody scale rows (MBR)—number of longitudinal scale rows around body counted midway between axilla and groin; paravertebral scales (DSR)—number of scales in a paravertebral row from first scale posterior to parietal scale to last scale at level of vent opening; fourth finger (FFS) and toe (FTS) scales—number of dorsal scales on fourth digit of hand and foot, distal scale contains claw, basal scale of fourth finger incorporates basal scale of adjacent third finger, and basal scale of fourth toe broadly contacts basal scale of adjacent third toe; fourth finger (FFL) and toe (FTL) lamellae—number of ventral scales on fourth digit of hand and foot, distal scale contains claw and basal scale is last largely undivided scale at, or proximal to, a point level with intersection of third and fourth digits. Bilateral scalation characters were scored on both sides and the mean value used in the species accounts and tables, but are expressed individually for types as left/right values respectively. Sexual dimorphism in paravertebral scales (the scalation character most likely to exhibit this trait) was assessed using independent two-sample *t*-test for the largest population. Variation between populations in scalation was assessed using independent two-sample *t*-tests for all scalation characters. Characters with a *P* value  $\leq 0.05$  are provided, however only those with a high *P* value  $\leq 0.001$  are considered likely to reflect unambiguous differences between populations.

Osteology. Specimens were X-rayed for counting the number of presacral vertebrae and postsacral vertebrae on complete original tails only.

Reproduction. The distribution of eggs in gravid females is expressed as left/right values for the number of eggs in the left and right oviducts respectively.

### Species descriptions

#### Genus *Sigaloseps* Sadlier, 1986.

This genus contains two species of small to moderately small scincid lizard, *Sigaloseps deplanchei* and *Sigaloseps ruficauda* n.sp., both endemic to New Caledonia. Both species are restricted to the south of the island, *S. deplanchei* is moderately widespread in closed forest habitat throughout its range and *S. ruficauda* is known only from two high altitude sites.

**Type species.** *Lygosoma deplanchei* Bavay, 1869: 23.

**Diagnosis.** *Sigaloseps* is identified as a member of the *Eugongylus* group of skinks (Greer, 1979) by possessing the following combination of synapomorphies: parietal scales meet behind the interparietal; parietal bordered along its posterior edge by upper secondary temporal/s and transversely enlarged nuchal scale; presacral vertebrae  $> 26$ .

Within the *Eugongylus* group, *Sigaloseps* possesses the following suite of derived character states: (a) supranasals absent; (b) frontoparietals fused; (c) ear lobules very small; (d) body scales smooth; (e) basal finger scales of 3rd and 4th fingers generally fused to form a single broad scale. It also has the atlantal arches fused to the intercentrum and is therefore included in the monophyletic *Pseudemoia* subgenus (Greer, 1989).

#### *Sigaloseps ruficauda* n.sp.

Figs. 1–6

**Type material.** HOLOTYPE: AMS R146482 Mt Mou, New Caledonia 22°03'45"S 166°20'39"E (R. Sadlier and P. Rowland, 16.i.95). PARATYPES: MNHN 1997.3325 (formerly AMS R146481) Mt Mou, New Caledonia 22°04'01"S 166°20'34"E; AMS R146483, R146196–97, MNHN 1997.3326 (formerly AMS R146198) same data as holotype; AMS R148004 Mt Mou, New Caledonia 22°03'42"S 166°20'41"E; AMS R148024 Mt Ouin 22°00'34"S 166°27'26"E.

**Etymology.** The species epithet is from the Latin *rufus*, for red, and *cauda*, for tail. The name alludes to the bright reddish colour of the tail in both sexes of this species.

**Diagnosis.** *Sigaloseps ruficauda* is distinguished from *Sigaloseps deplanchei* by the following combination of characters: (a) larger adult size (maximum SVL 60 vs 46 mm); (b) more numerous paravertebral scales (53–60 vs 46–56); (c) longer tail (tail length 150 vs 100% SVL); (d) more postsacral vertebrae 47–49 vs 35–39; (e) a uniform bright orange to reddish tail colour overall in both sexes (vs dull orange markings); (f) and well defined and



**Figure 1.** Paratype of *Sigaloseps ruficauda* n.sp. (AMS R146483), an adult female.

continuous dorsolateral markings between eye and forelimb (vs a series of broken markings in this region).

**Description.** The species is known from five adults 38–60 mm SVL, and three juveniles 25–27 mm SVL. Measurements are for adults only.

**Measurements.** Distance from axilla to groin 54.7–58.3% SVL ( $\bar{x}$  = 55.7,  $n$  = 5); distance from forelimb to snout 35.7–39.6% SVL ( $\bar{x}$  = 37.8,  $n$  = 5); hindlimb length 30.0–36.8% SVL ( $\bar{x}$  = 32.9,  $n$  = 5); tail length 152.6% SVL ( $n$  = 1).

**Scalation.** Frontonasal broader than long; prefrontals narrowly-moderately separated; frontal longer than wide; frontoparietals fused; interparietal distinct; parietal bordered by a nuchal and upper secondary temporal scale; primary temporal single; upper secondary temporal single and overlapping lower; lower secondary temporal single; tertiary temporals two; postlabials two; nasals moderately large, moderately to widely separated; supraciliaries usually seven (83.3%), rarely six or eight; upper labials seven, fifth subocular and contacting lower eyelid; lower labials six, first two contacting postmental; large chinshields three, members of first pair in broad contact, members of second pair separated by one scale, members of third pair separated by three scales, all chin scales flush with lower labials.

Lower eyelid with a centrally located semi-transparent disc, length approximately 30% of total eye length.

Ear opening moderately large, with small acute lobules anteriorly and a number of small rounded lobules on posterior and lower edges.

Body scales smooth, midbody scale rows 26–28 ( $\bar{x}$  = 26,  $SD$  = 0.93,  $n$  = 8); paravertebral scales 53–60 ( $\bar{x}$  = 56.1,  $SD$  = 2.47,  $n$  = 8).

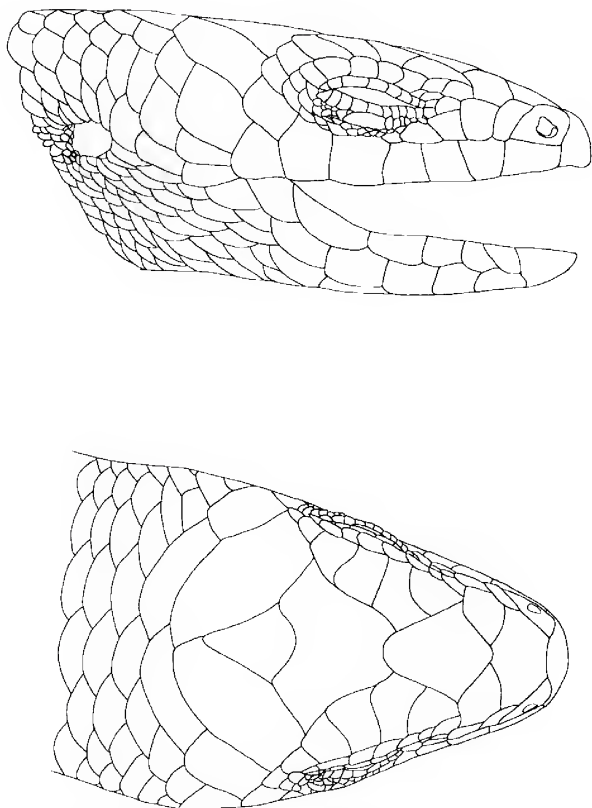
Basal scales of third and fourth fingers usually fused to form a single broad scale (69%), occasionally separate; scales on top of fourth finger 7–9 ( $\bar{x}$  = 8.1,  $SD$  = 0.69,  $n$  = 8); lamellae beneath fourth finger 9–13 ( $\bar{x}$  = 11.8,  $SD$  = 1.67,  $n$  = 8); scales on top of fourth toe 11–13 ( $\bar{x}$  = 11.0,  $SD$  = 1.03,  $n$  = 8); lamellae beneath fourth toe 21–28 ( $\bar{x}$  = 25.0,  $SD$  = 1.98,  $n$  = 5), smooth and broad.

**Osteology.** Premaxillary teeth 11 ( $n$  = 2); presacral vertebrae 29; postsacral vertebrae 47–49 ( $\bar{x}$  = 47.5,  $SD$  = 0.93,  $n$  = 4); phalangeal formula for manus and pes 2.3.4.5.3 and 2.3.4.5.4 respectively; 2 pairs of ribs contacting mesosternum.

**Coloration.** Mid to dark brown dorsally and laterally; both dorsal and upper lateral surfaces (including head) with dark markings aligned longitudinally giving the appearance of a series of broken lines the intensity of which varies between individuals but is at least obvious anteriorly; dorsolateral edge with a dark bar between eye and naris, and a lighter dark edged russet stripe (approximately one scale width) between eye and forelimbs, merging with the general body colour posterior of forelimbs; tail unmarked above and with scattered dark markings below, bright orange-reddish in life; ventral surface usually without dark markings, in life with a yellow flush to the chest and abdomen and pink flush to the throat. The holotype has obvious black markings on the throat which are absent from other adult females in the type series.



**Figure 2.** Paratype of *Sigaloseps ruficauda* n.sp. (AMS R148004), an adult male.



**Figure 3.** Lateral and dorsal views of the head of holotype of *Sigaloseps ruficauda* n.sp. (AMS R146482).

Dorsal surface of the single adult male lighter anteriorly with a dull russet suffusion (including pale dorsolateral edge between the eye and forelimbs), whereas this region tended to be nearly uniform in colour in adult females.

**Details of holotype.** Adult female; size 56 mm SVL; distance from axilla to groin 31 mm; distance from forelimb to snout 20 mm; hindlimb length 17 mm; tail length 64 mm, reproduced.

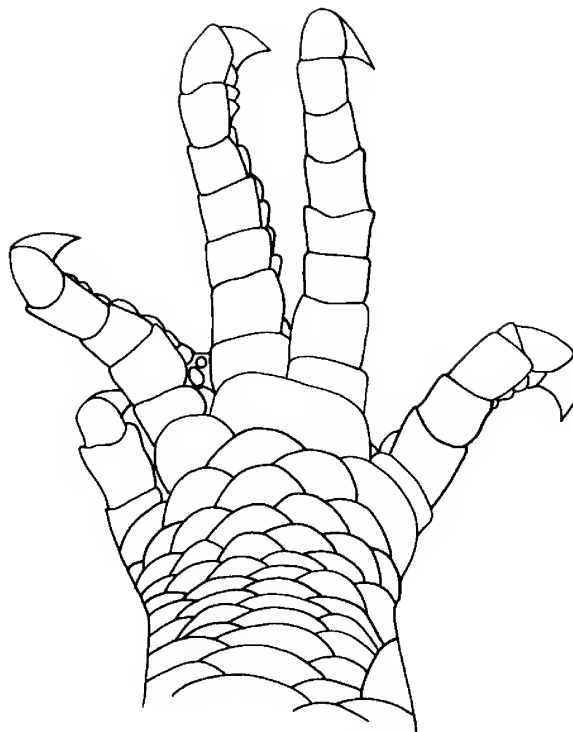
Midbody scale rows 26; paravertebral scale rows 58; dorsal scales of fourth finger 9/9; lamellae of fourth finger 13/12; dorsal scales of fourth toe 12/12; lamellae of fourth toe 25/25.

Gravid with 3 (1/2) shelled oviductal eggs.

**Distribution.** Summits of Mt Ouin (1,100 m asl) and Mt Mou (1,120–1,150 m asl) in southern New Caledonia.

**Biology.** *Sigaloseps ruficauda* is known only from low closed forest near the summit of Mt Ouin and maquis shrubland adjacent to low closed forest near the summit of Mt Mou.

Maquis is a heathy formation on ultrabasic rocks, it includes 30% of the native species, 36% of the genera, and 47% of the families, 93% of the species are endemic to New Caledonia (Morat *et al.*, 1986). On Mt Mou the high altitude maquis has a dense understorey of ferns. *Sigaloseps ruficauda* was collected among the jumbled rocks covered by the understorey. The environment beneath the rocks was cool and moist. Specimens were also collected from beneath



**Figure 4.** Dorsal view of the hand of *Sigaloseps ruficauda* n.sp. (AMS R146482) showing fusion of basal scales of the third and fourth digits (typical also of *Sigaloseps deplanchei*).

rocks at the interface of the maquis and adjacent closed forest habitat at approximately 1,100 m, here the environment beneath the rocks was also cool and moist. *Sigaloseps ruficauda* was not recorded from the interior of high altitude closed forest on Mt Mou, although this may be due to the limited number of sheltering sites to search. The single Mt Ouin specimen was found under a pile of rocks and wet earth in a track cutting through closed forest.

Two adult females collected on Mt Mou in 16 January were gravid (SVL 48 and 56 mm) and contained 3 shelled oviductal eggs. A clutch of several eggs was found at Mt Mou on 16 January under a small stone beside the track, the young at hatching measured approximately 25–27 mm snout-vent length.

**Conservation status.** The limited data available indicates *Sigaloseps ruficauda* is restricted to the tops of ranges in the south of the island. Its broader distribution is likely to be as a number of scattered relictual populations between 900–1,200 m altitude. The occurrence of *Sigaloseps ruficauda* at the two known sites appears to be based less on vegetation type than on other variables, such as habitat structure (presence of sheltering sites) and possibly moisture. It is therefore difficult to predict its distribution throughout the region.

Mining activity on the mid to upper slopes of the New Caledonian ranges is most prevalent in the central ranges of the island and on isolated peaks on the west coast. Mining at high altitude in the southern New Caledonia is at present



limited. However, should it be extended to areas where *Sigaloseps ruficauda* is likely to occur, it could have a marked negative impact upon on this and other reptile species restricted to high altitude habitat in the region.

Neither of the known populations of *Sigaloseps ruficauda* are currently protected within a fauna reserve, although the population on Mt Mou is within the Mont Mou Réserve Spéciale Minières et Botanique. Collection and disturbance of minerals and vegetation in this reserve is prohibited, and therefore there is some protection to habitat within the reserve.

Because of the restricted nature of its distribution and apparently restricted habitat preferences *Sigaloseps ruficauda* could conservatively be regarded as Vulnerable:D2 under the current IUCN (1996) classification system (very small population or very restricted distribution; population is susceptible; area of occupancy <100 km<sup>2</sup> or number of locations <5). When the fragmented nature of its distribution is also taken into account, any human activity in the region which could threaten its preferred habitat would place this species in a higher category of risk. A further consideration is its known occurrence lies outside of designated fauna reserves.

Field research to further determine the species distribution and habitat preferences (particularly the extent of its reliance upon high altitude maquis habitat) are required before its conservation status and the potential impact of development on the species can be determined with certainty.



**Figure 5.** Habitat at the type locality for *Sigaloseps ruficauda* n.sp., at approximately 1,100 m asl on Mt Mou, New Caledonia.

### *Sigaloseps deplanchei* (Bavay)

Figs. 4, 6, 7

The description of *Lygosoma deplanchei* by Bavay (1869) lists only a single set of measurements but refers to the species as having been encountered more than once. It was one of eight new scincid lizards described by him from New Caledonia for which no types were designated at the time of description, nor any indication as to where the specimens on which the descriptions were based were lodged.

Boulenger's (1887) account of *Lygosoma deplanchei* listed as material in The Natural History Museum, London (BMNH) two types from New Caledonia presented by Bavay (now registered as BMNH 86.9.16.1-2), and the single type of *Hinulia tetragonurus* Günther. Günther's (1872) description of *Hinulia tetragonurus* is one of four new scincid lizards purportedly obtained from the "Feejee Islands"—all of which are synonymous with New Caledonian species already described by Bavay (see Sadlier 1986: 4, for more detail).

Roux (1913) provided the first comprehensive description of the species based on specimens collected by Roux and Sarasin in 1911–12. This collection (12 specimens are registered in the NHMB) came from two localities on the east coast, Yaté and Ngoi.

Some of Bavay's specimens were recently discovered in the Museum National d'Histoire Naturelle Paris, among them, three syntypes of *Lygosoma deplanchei* Bavay (Brygoo, 1985).

Sadlier (1986) reviewed the species and erected the monotypic genus *Sigaloseps* to accommodate *Lygosoma deplanchei* Bavay. This review was based largely on the specimens collected by Roux and Sarasin, together with the BMNH syntypes of *Lygosoma deplanchei* and *Hinulia tetragonurus*, and five specimens from other sources. Unaware of the recent discovery of several syntypes in the MNHN, Sadlier designated a lectotype for *Lygosoma deplanchei* from one (BMNH 86.9.16.1) of the two BMNH syntypes.

In the past 13 years (1986–1998) more intensive field research has resulted in the acquisition of additional specimens from a broad range of localities. This additional material is the basis for the more detailed description of *Sigaloseps deplanchei* that follows.

**Material examined.** The redescription of *Sigaloseps deplanchei* (below) is based on the following series of specimens:

West coast and ranges: AMS R144348–49, R144352, R146546–60, 146576–84, R146587 Mt Koghis (500 m) 22°10'S 166°30'E; R135167–69 Yahoué Valley, Nouméa 22°13'S 166°30'E; R147849 Fôret Thy 22°11'S 166°37'E; R78246–47 Mt Dore (eastern base), 2 km W Plum turnoff on Mt Dore road 22°17'S 166°37'E.

Plaine des Lacs region: AMS R125824, R125899, R135609–11 Rivière Bleue, Kaori Géant 22°06'S 166°39'E; R125895 Rivière Bleue, 1 km E Kaori Géant 22°06'S 166°39'E; R147916 Rivière Bleue, Haute Rivière Bleue Walk 22°05'S 166°37'E, R147952–53 Rivière Bleue, 4.7 km E Pont Germain 22°06'S 166°41'E; R147954 Rivière

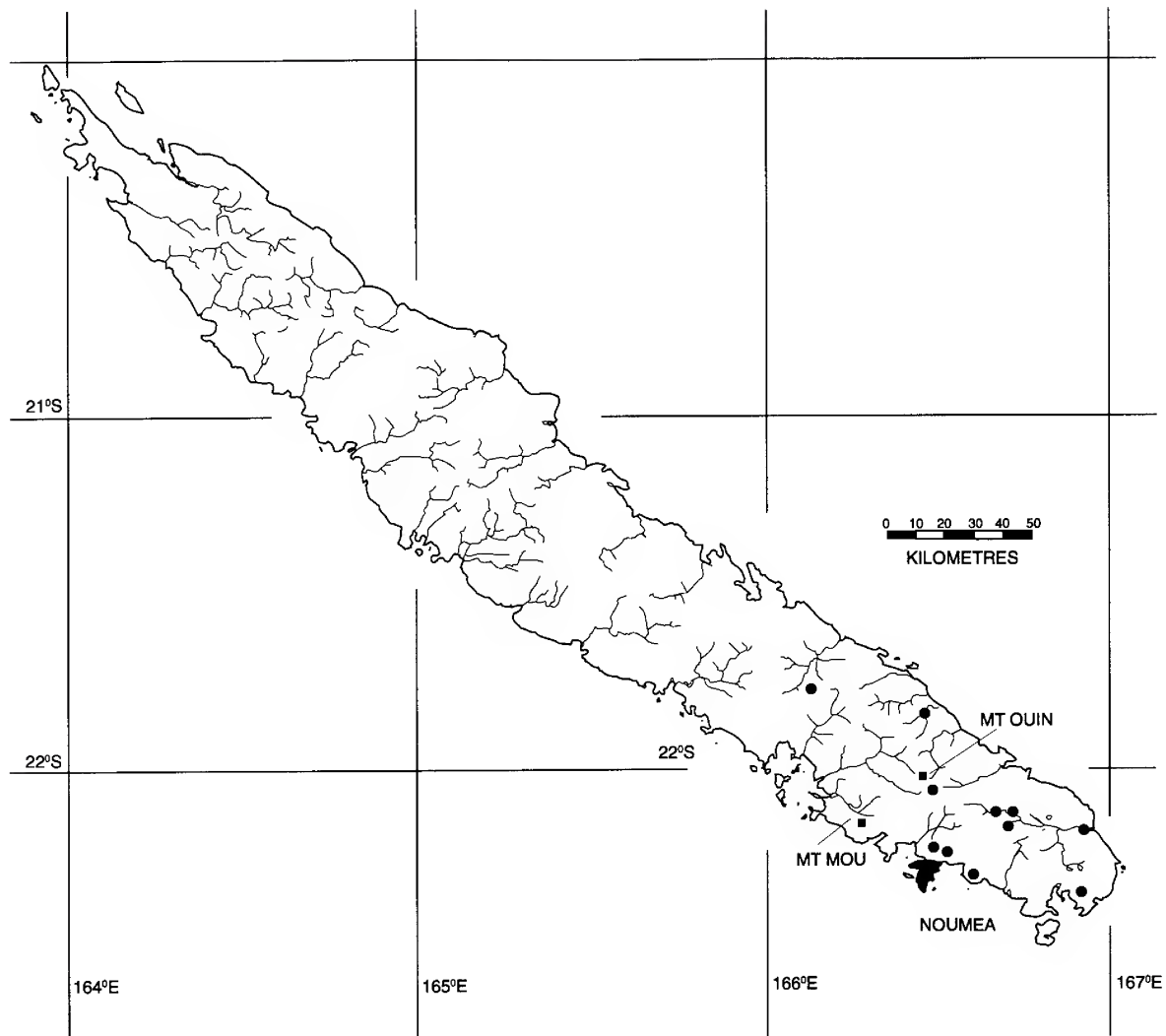


Figure 6. Records of *Sigaloseps ruficauda* n.sp. (■) and *Sigaloseps deplanchei* (●) in southern New Caledonia.

Bleue, Hoop Géant 22°09'S 166°41'E; R148063–67 Fôret Nord on SW base of Kwa Née 22°19'S 166°54'E; CAS 158391–92 Mt Aiguillon (= Kwa Née 22°19'S 166°54'E).

East coast: CAS 157690–91, 158336–42, 162352–53 Goro 22°17'S 167°01'E; NHMB 7198–201, 7205 Yaté 22°09'S 166°55'E.

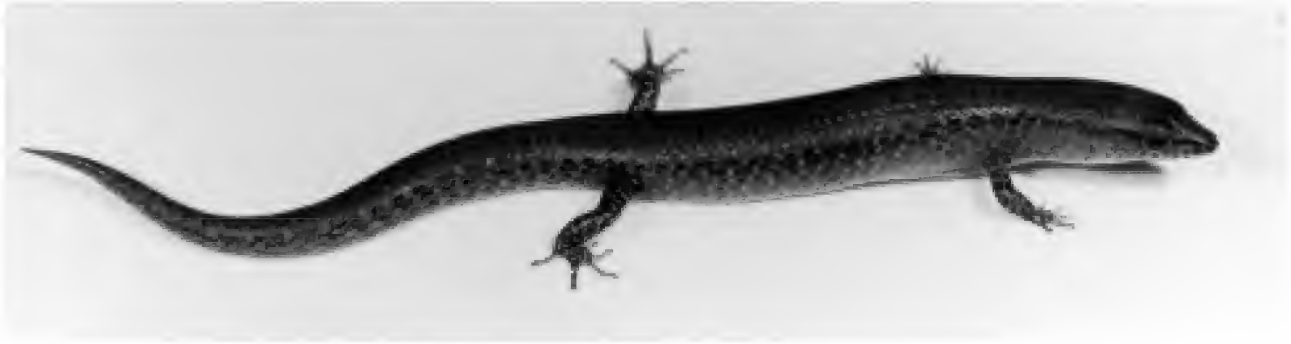
The following specimens were also examined and are used in compiling the general distribution of *Sigaloseps deplanchei*, but were not used in the redescription (below): AMS R150066 headwaters of Ni River, east of Mt Ouin (745 m) 21°59'S 166°30'E; AIM 1716, 1718, 1730, 1748–49, 1751–52, 1774 Pic Ningua 21°45'S 166°08'E.

**Diagnosis.** See account for *Sigaloseps ruficauda*.

**Description.** *Measurements* (adults only): maximum SVL 46 mm; distance from axilla to groin 50–61.1% SVL ( $\bar{x}$  = 55.5,  $n$  = 57); distance from forelimb to snout 36.8–43.6% SVL ( $\bar{x}$  = 39.5,  $n$  = 57); hindlimb length 28.6–34.4% SVL

( $\bar{x}$  = 31.6,  $n$  = 55); tail as long, or slightly shorter or longer than body 87.5–110.8% SVL ( $\bar{x}$  = 100.4,  $n$  = 21).

*Scalation.* Frontonasal broader than long; prefrontals narrowly to moderately separated, rarely widely separated; frontal longer than wide; frontoparietals fused; interparietal distinct; parietals each bordered by a nuchal and upper secondary temporal; nuchals occasionally divided to form two smaller equal size scales, and occasionally separated and not contacting medially along the vertebral axis; primary temporal single (93%,  $n$  = 64), rarely divided obliquely to form two similar sized scales; upper secondary temporal single and overlapping lower; lower secondary temporal single (98.4%,  $n$  = 64), very rarely divided obliquely to form two near similar sized scales; tertiary temporals two; postlabials two; nasals moderately large, usually widely separated; supraciliaries usually seven (87.3%,  $n$  = 63), occasionally six; upper labials seven, last very rarely divided by an oblique suture; lower labials six; postmental contacting second lower labial; large chinshields three,



**Figure 7.** *Sigaloseps deplanchei* from Mt Koghis in southern New Caledonia.

members of first pair in broad contact, members of second pair separated by one scale, members of third pair separated by three scales, all large chin scales flush with lower labials.

Lower eyelid with a large opaque disc centrally (approximately 30% of eye length), which in some individuals is variably divided by one or more transverse sutures to give the appearance of a scaled lower eyelid.

Ear opening moderately large and with 2–4 small acute lobules anteriorly, and a number of small rounded lobules on posterior and lower edges.

Body scales smooth, midbody scale rows 24–28 ( $\bar{x}$  = 27.1, SD = 1.43,  $n$  = 62); paravertebral scales 46–56 ( $\bar{x}$  = 50.6, SD = 2.35,  $n$  = 62).

Basal scales of third and fourth fingers usually fused to form a single broad scale (94%), occasionally separate; scales on top of fourth finger (including basal scale) 7–9 ( $\bar{x}$  = 7.9, SD = 0.47,  $n$  = 58); lamellae beneath fourth finger 10–15 ( $\bar{x}$  = 11.9, SD = 0.87,  $n$  = 54); scales on top of fourth toe 10–12 ( $\bar{x}$  = 11.1, SD = 0.37,  $n$  = 59); lamellae beneath fourth toe 24–29 ( $\bar{x}$  = 25.9, SD = 1.44,  $n$  = 54), broad.

There was no significant difference between the sexes of the largest sample from mid altitude on Mt Koghis (13 males and 12 females respectively) for midbody scale rows ( $\bar{x}$  = 27.9 vs 28.1,  $t_{23}$  = -0.612,  $P$  = 0.547), paravertebral scales ( $\bar{x}$  = 52.1 vs 52.8,  $t_{23}$  = -0.906,  $P$  = 0.347), scales on top of fourth finger (including basal scale) ( $\bar{x}$  = 8.1 vs 8.2,  $t_{23}$  = -0.853,  $P$  = 0.403), lamellae beneath fourth finger ( $\bar{x}$  = 12.0 vs 12.1,  $t_{22}$  = -0.230,  $P$  = 0.821), scales on top of fourth toe ( $\bar{x}$  = 11.3 vs 11.0,  $t_{23}$  = 1.357,  $P$  = 0.188), lamellae beneath fourth toe ( $\bar{x}$  = 26.1 vs 25.9,  $t_{23}$  = 0.386,  $P$  = 0.703).

**Osteology.** Premaxillary teeth 10–11 ( $n$  = 2); presacral vertebrae usually 29 ( $n$  = 60), occasionally 28 ( $n$  = 2) or 30 ( $n$  = 3); postsacral vertebrae 35–39 ( $n$  = 4); phalangeal formula for manus and pes 2.3.4.5.3 and 2.3.4.5.4 respectively ( $n$  = 54); 2 pairs of mesosternal ribs contacting mesosternum; atlantal arches fused to the intercentrum.

**Coloration.** Dorsal surface light to mid-brown, occasionally darker, uniform or variably marked with darker streaks aligned longitudinally to give the appearance of a series of broken lines; lateral surface paler than dorsal, most individuals with a concentration of dark flecks uppermost, tending to be most prominent at the dorsolateral edge of the body; side of head with dark markings, particularly on labial scales and along dorsolateral margin where a dark streak runs from the naris through to near the level of the ear opening; ventral surface yellow posterior to the level of

the forelimb and with an orange to pinkish flush to the throat.

There is obvious sexual dimorphism in ventral coloration between adult males and females. Ventral surface of adult males bold yellow posterior to the level of the forelimb, and with a bright orange throat; adult females not so brightly marked, moderate yellow on the abdomen and with a dull pinkish flush to the throat; subadults with no obvious colour to the abdomen and a dull pinkish flush to the throat.

**Geographic variation.** Across the range of samples geographic variation was observed in seven scalation characters.

There was a trend for samples from the southeast coast at Ngoi (100%,  $n$  = 2) and Yaté (83%,  $n$  = 6) and from the southeast ranges at Rivière Bleue (78%,  $n$  = 9) to have a complete subocular row of scales, whereas those from the Plaine des Lacs region at Kwa Néie ( $n$  = 5) and from the west side of the island at or near the Koghis Range (Mt Koghis  $n$  = 28, Yahoué Valley, Mt Dore and Forêt Thy collectively  $n$  = 8) all had the subocular upper labial contacting the lower eyelid. Samples from Goro ( $n$  = 12) on the east coast (only 20 km south of Yaté) are more similar to the adjacent sample at Kwa Néie (10 km east) on the Plaine des Lacs in having the subocular upper labial contacting the lower eyelid.

The same samples were assessed for interpopulation variation in the following six variable scalation characters (see Table 1): midbody scale rows (MBR), paravertebral scales (DSR), fourth finger (FFS) and toe (FTS) scales, and fourth finger (FFL) and toe (FTL) lamellae. There was significant variation in several characters between populations from the southeast coast (Yaté and Goro), the southeast ranges (Rivière Bleue), Plaine des Lacs region (Kwa Néie), or low altitude populations at or near the base of the Koghis range (Yahoué Valley, Mt Dore and Forêt Thy). The sample from Goro had fewer paravertebral scales than the Rivière Bleue ( $t_{18}$  = -2.385,  $P$  = 0.028) sample; the Yaté sample fewer fourth toe scales than the Rivière Bleue ( $t_{12}$  = -2.518,  $P$  = 0.027) sample; and the Goro sample more fourth toe scales than the Yaté ( $t_{13}$  = 2.404,  $P$  = 0.032) sample. There were significant differences between these populations and the mid-altitude population from the Koghis range in midbody scale rows, paravertebral scales, fourth finger scales and lamellae, and fourth toe scales. The Koghis range mid altitude sample had significantly: more midbody scale rows than the Yaté ( $t_{30}$  = 4.954,  $P$  < 0.001), Goro ( $t_{36}$  =



7.907,  $P < 0.001$ ), Rivière Bleue ( $t_{34} = 7.315$ ,  $P < 0.001$ ), or Koghis low altitude ( $t_{32} = 4.806$ ,  $P < 0.001$ ) samples; more paravertebral scales than the Yaté ( $t_{30} = 4.247$ ,  $P < 0.001$ ), Goro ( $t_{36} = 6.114$ ,  $P < 0.001$ ), Kwa Née ( $t_{29} = 3.848$ ,  $P < 0.001$ ), Rivière Bleue ( $t_{34} = 3.377$ ,  $P < 0.002$ ), or Koghis low altitude ( $t_{32} = 3.787$ ,  $P < 0.001$ ) samples; more fourth finger scales than Goro ( $t_{34} = 2.163$ ,  $P = 0.038$ ), Yaté ( $t_{30} = 4.431$ ,  $P < 0.001$ ), Kwa Née ( $t_{29} = 3.529$ ,  $P < 0.001$ ), or Rivière Bleue ( $t_{34} = 3.535$ ,  $P < 0.001$ ) samples; more fourth toe scales than the Yaté ( $t_{30} = 2.729$ ,  $P = 0.011$ ) sample; and more fourth finger lamellae than the Yaté ( $t_{28} = 2.155$ ,  $P = 0.040$ ) sample.

The differences in scalation between the low altitude populations at the base of the Koghis range and the regionally sympatric populations on the Koghis range at mid altitude could be viewed in two ways. Firstly as an indication of genetic differentiation between populations at low and high altitude, or as variation in scalation over an altitudinal gradient within a single species i.e., an increase in number of scales with altitude. To further test the first of these possibilities additional high altitude samples from different locations are required. Unfortunately the specimens from high altitude (900–1,000 m asl) at Pic Ningua are from formalin-based pit-fall trap samples and their state of preservation is such that the characters cannot be assessed accurately. To test the second possibility would require samples from the Koghis range at intermediate altitudes between 300 m and 700 m asl.

**Distribution.** Southern third of New Caledonia to as far north as Pic Ningua (21°45'S 166°08'E), approximately 16 km northeast of the town of Bouloupari. The single specimen of *Sigaloseps deplanchei* collected from the headwaters of Ni River, east of Mt Ouin at mid to high altitude (745 m) is the geographically closest site to the Mt Ouin location for *S. ruficauda*.

**Biology.** *Sigaloseps deplanchei* occurs in lowland and mid (500 m) to high altitude (1,000+ m) closed forest habitat where it can be relatively abundant. It is a secretive species usually found sheltering beneath rocks, logs, and debris on the forest floor but is occasionally observed active in leaf litter. When active it moves constantly amongst the litter and was not observed to actively bask in sunlit patches.

Gravid females have been collected during the summer (wet season) month of December. Modal clutch size is two,

with three eggs recorded occasionally. A sample of six adult females collected on Mt Koghis (500 m asl) in December 1986 had two ( $n = 5$ ) to three ( $n = 1$ ) oviductal eggs, whereas a sample of 10 adult females from the same location collected in January 1995 had flaccid oviducts ( $n = 9$ ) indicating egg laying had occurred, or yolked ovarian follicles ( $n = 1$ ).

**Conservation status.** *Sigaloseps deplanchei* is known from over ten sites scattered over much of the ultramafic area in southern New Caledonia. It was previously assessed as moderately widespread and common by Bauer & Sadlier (1993) based on the number of museum specimen records available at that time. It has since been recorded from several additional localities, most notably Pic Ningua which represents a significant range extension to the north, indicating the species is likely to be more widespread in the southern ultramafic region of the island than previous records indicated.

At Mt Koghis, which has been visited repeatedly, *Sigaloseps deplanchei* is common in mid-altitude (500 m asl) closed forest habitat; it has also been collected on successive occasions at several other sites (Goro, Kwa Née, Rivière Bleue). Because of its moderately widespread distribution *Sigaloseps deplanchei* is considered secure at the island level, and would be regarded as Lower Risk:lc under the current IUCN classification system (1986). However, because it is restricted to closed forest habitat, populations of *S. deplanchei* in the more highly developed west coast lowlands are likely to be threatened at a local level by human activities in these areas.

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**Table 1.** Variation in scalation characteristics for *Sigaloseps deplanchei* from six locations throughout the species range.

			MBR	DSR	FFS	FFL	FTS	FTL
Yaté	range		26–28	47–51	7–8	10–12	10–11	23–26
	$\bar{x}$		26.4	48.8	7.4	11.2	10.6	24.9
	SD		0.89	1.89	0.55	0.76	0.42	1.89
	n		5	5	5	5	5	4
Goro	range		24–28	46–51	7–8	10–12	10–12	22–28
	$\bar{x}$		26.0	48.4	7.9	11.8	11.0	25.8
	SD		0.89	2.01	0.33	0.76	0.24	1.85
	n		11	11	9	7	10	8
Kwa Née	range		26	47–51	7–8	11–13	11–12	25–27
	$\bar{x}$		26.0	49.8	7.5	12.0	11.1	25.9
	SD		0.0	1.71	0.58	0.71	0.25	0.75
	n		4	4	4	4	4	4
Rivière Bleue	range		26–28	48–52	6–8	11–14	11–12	25–28
	$\bar{x}$		26.2	50.2	7.6	11.9	11.1	26.4
	SD		0.67	1.30	0.6	0.81	0.33	1.28
	n		9	9	9	9	9	7
Mt Koghis Range (mid altitude)	range		26–30	49–55	8–9	11–15	10–12	23–29
	$\bar{x}$		28.0	52.4	8.2	12.2	11.2	26.1
	SD		0.62	1.78	0.30	0.93	0.41	1.48
	n		27	27	27	25	27	26
Mt Koghis Range (low altitude)	range		26–28	48–51	7–8	10–13	10–11	25–27
	$\bar{x}$		27.6	49.7	7.9	11.2	10.9	25.4
	SD		0.98	1.11	0.38	0.76	0.38	0.65
	n		7	7	7	7	7	5





# **The Scincid Lizard *Lioscincus tillieri* (Reptilia: Scincidae) from New Caledonia in the Southwest Pacific: New Information on the Species' Biology, Distribution and Morphology**

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**ABSTRACT.** *Lioscincus tillieri* was originally described in 1991 from a single juvenile specimen. Field observations on the species at several localities and the acquisition of a further fifteen specimens collected between 1995 and 1998 have provided new data on its biology, distribution, and morphology. Most notably *L. tillieri* is now known to have a live-bearing mode of reproduction, only the second occurrence of viviparity in the endemic New Caledonian skink fauna.

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The New Caledonian scincid lizard *Leiolopisma tillieri* was described by Ineich & Sadlier (1991) from a single specimen collected by entomologists in a malais trap set in Parc Rivière Bleue in the Plaine des Lacs region in the south of the island. The specimen was small (snout to vent length 29.5 mm) and presumed to be a juvenile.

At the time of description it was not possible to unambiguously assign the species to any existing monophyletic genus in the *Eugongylus* group of skinks (Greer, 1979). For this reason it was placed in “*Leiolopisma*” which comprised an essentially primitive assemblage of species from Australia, New Zealand, New Caledonia, and Mauritius (where the type species *Leiolopisma telfairi*

occurs on Round Island). In the past 10 years there has been a progressive dismantling of the polyphyletic genus *Leiolopisma* (see Hutchinson *et al.*, 1990). The New Caledonian species placed in *Leiolopisma* by Sadlier (1986) have subsequently been reallocated to *Lioscincus* (Bauer & Sadlier, 1993), the next available generic name to accommodate these taxa. As it currently stands *Lioscincus* includes: *L. greeri*, *L. maruia*, *L. nigrofasciolatum*, *L. novaecaledoniae*, *L. steindachneri* (type species), and *L. tillieri*, but still remains an assemblage of generally primitive *Eugongylus* group species.

In overall morphology *L. tillieri* is most similar to the recently described New Caledonian species *Lioscincus*

*maruia* Sadlier *et al.* (1998) and the species of *Tropidoscincus* (also from New Caledonia), most significantly in also having an extremely long tail with 60 or more postsacral vertebrae. However both *L. tillieri* and *L. maruia* lack the unusual skeletal character in the region of the mesosternum that characterises *Tropidoscincus* (as defined by Sadlier, 1986), i.e. the species of *Tropidoscincus* have three mesosternal ribs whereas *L. tillieri* has two, the latter being the primitive character state for the *Eugongylus* group.

Known only from the single juvenile specimen collected in 1991, *Lioscincus tillieri* was listed as rare by Bauer & Sadlier (1993) in an assessment of the distribution and status of the endemic lizards of New Caledonia. The species was not collected again until 1995 when it was located in maquis shrubland on Mt Mou and Mt Vulcain during the course of two periods of field research that traversed that habitat type. Since then it has been located at a further three locations in the south of the island, always in maquis shrubland. The information presented here is a compilation of both opportunistic, and more recently, targeted field research carried out over a number of years. The acquisition of additional specimens has provided data on variation in scalation and osteology, colour pattern in adults, and reproductive mode, all previously unreported.

### Materials and methods

Specimen abbreviations are prefixed as follows: Australian Museum (AMS); California Academy of Sciences (CAS); Museum National d'Histoire Naturelle Paris (MNHN).

Measurements. The following characters were scored for each specimen where possible: snout to vent length (SVL)—measured from tip of snout to caudal edge of anal scales; axilla to groin distance—measured from middle of base of the forelimb to middle of base of hindlimb; forelimb to snout length—measured from tip of snout to middle of base of forelimb; hindlimb length—measured from middle of base of hindlimb to tip of fourth toe including nail; tail length—measured from caudal edge of anal scales to tip of tail, on complete original tails only. Body measurements are for adults only, as determined by reproductive maturity (presence of enlarged, yolked ovarian follicles or embryos in females and enlarged testes in males) and/or obvious size classes, and are expressed as percentages of snout to vent length in the taxon accounts.

Scalation. Head scalation generally follows Taylor (1935) as described and figured by Sadlier (1986); midbody scale rows—number of longitudinal scale rows around body counted midway between fore and hindlimb; paravertebral scales—number of scales in a paravertebral row from first scale posterior to parietal scale to last scale at level of vent opening; fourth finger and toe scales—number of dorsal scales on fourth digit of hand and foot, distal scale contains claw and basal scale broadly contacts adjacent basal scale of third finger or toe; fourth finger and toe lamellae—number of ventral scales on fourth digit of hand and foot, distal scale contains claw and basal scale is last largely undivided scale to a point level with intersection of third and fourth digits. Bilateral characters were scored on both sides and the mean value used.

Osteology. Specimens were X-rayed to assess phalangeal formula, and the number of presacral and postsacral vertebrae.

### Species account

#### *Lioscincus tillieri* (Ineich & Sadlier)

Figs. 1–4

*Leiolopisma tillieri* Ineich & Sadlier, 1991: 343.

**Material examined.** AMS R148032–33 Mt Vulcain, Mine Galliéni 21°54'S 166°20'E (500 m); AMS R148035–38 Mt Vulcain, vicinity Refuge du Vulcain 21°54'S 166°23'E (970 m); AMS R146479 Mt Mou, 22°04'01"S 166°20'34"E (1,000–1,050 m); AMS R146486 Mt Mou 22°03'53"S 166°20'36"E (1,095 m); MNHN 1989.26 (holotype *Leiolopisma tillieri*), Rivière Bleue, 22°06'05"S 166°40'06"E (310 m); AMS R147909, R152616, R152628, CAS 205462 Rivière Bleue, 22°05'47"S 166°40'13"E; AMS R151335 Yaté (vicinity), 22°10'02"S 166°53'50"E (330 m).

**Diagnosis.** *Lioscincus tillieri* is distinguished from other species of *Lioscincus* by the following combination of characters: (a) scales of dorsal surface of body and tail with two strong keels; (b) midbody scale rows 34–38; (c) paravertebral scales 65–71; (d) lamellae under the fourth finger 18–23; (e) lamellae under the fourth toe 27–33; (f) parietals each bordered by a nuchal scale and 2 upper secondary temporal scales; (g) dorsal surface of head with a relatively unmarked uniform brown colour pattern.

**Description.** The description is based on 16 specimens comprising nine adults (three males and six females) 52–64 mm SVL, two subadults 41–45 mm SVL, and five juveniles 29.5–38 mm SVL (including the holotype). Measurements are for adults only (n = 9 unless otherwise stated); scalation was assessed on all specimens unless otherwise stated.

**Measurements.** Distance from axilla to groin 55.9–60.0% SVL ( $\bar{x}$  = 57.6); distance from forelimb to snout 36.1–40.0% SVL ( $\bar{x}$  = 38.0); hindlimb length 43.8–50.9% SVL ( $\bar{x}$  = 47.4); tail 279.2–296.4% SVL ( $\bar{x}$  = 288.6, n = 3).

**Scalation.** Frontonasal broader than long (W/L = 120–140%,  $\bar{x}$  = 128.3, n = 6); prefrontals moderately large, narrowly separated (56.25%), in point to narrow contact (25.0%), rarely more widely separated (12.5%) or contacting (6.25%); frontal longer than wide (W/L = 70.5–86.6%,  $\bar{x}$  = 78.5, n = 6), the holotype has the frontal fused to the frontoparietals; frontoparietals fused; interparietal distinct; parietals each bordered by a nuchal scale and two, rarely one, (6.2%) upper secondary temporal scales; primary temporal single; lower secondary temporal single; tertiary temporals usually two, occasionally three (9.4%); postlabials two; nasals moderately to widely separated; supraciliaries 4–7, usually 5 (34.4%) or 6 (56.2%), rarely 4 or 7, third usually elongate and bordering posterior half of first supraocular and nearly all of second supraocular; upper labials 7, rarely 6 (4.1%); lower labials 6, rarely 5 (4.1%); postmental contacting first and second lower labial; chinshields three, first pair in broad medial contact.



**Figure 1.** Male (upper) and female (lower) of *Lioscincus tillieri*.

Lower eyelid with an obvious semi-transparent disc, length approximately 33–38.5% ( $\bar{x}$  = 36.4,  $n$  = 6) of total eye length.

Ear opening moderately large and with enlarged lobules anteriorly.

Scales of body and tail with two strong keels; midbody scale rows 34–38 ( $\bar{x}$  = 35.1,  $SD$  = 1.23,  $n$  = 16); paravertebral scales 65–71 ( $\bar{x}$  = 68.3,  $SD$  = 1.85,  $n$  = 16); scales on top of fourth finger 15–18 ( $\bar{x}$  = 17.1,  $SD$  = 0.51,  $n$  = 16); lamellae beneath fourth finger 18–23 ( $\bar{x}$  = 20.3,  $SD$  = 1.00,  $n$  = 16); scales on top of fourth toe 21–25 ( $\bar{x}$  = 22.6,  $SD$  = 1.07,  $n$  = 16); lamellae beneath fourth toe 27–33 ( $\bar{x}$  = 30.5,  $SD$  = 1.76,  $n$  = 16), smooth.

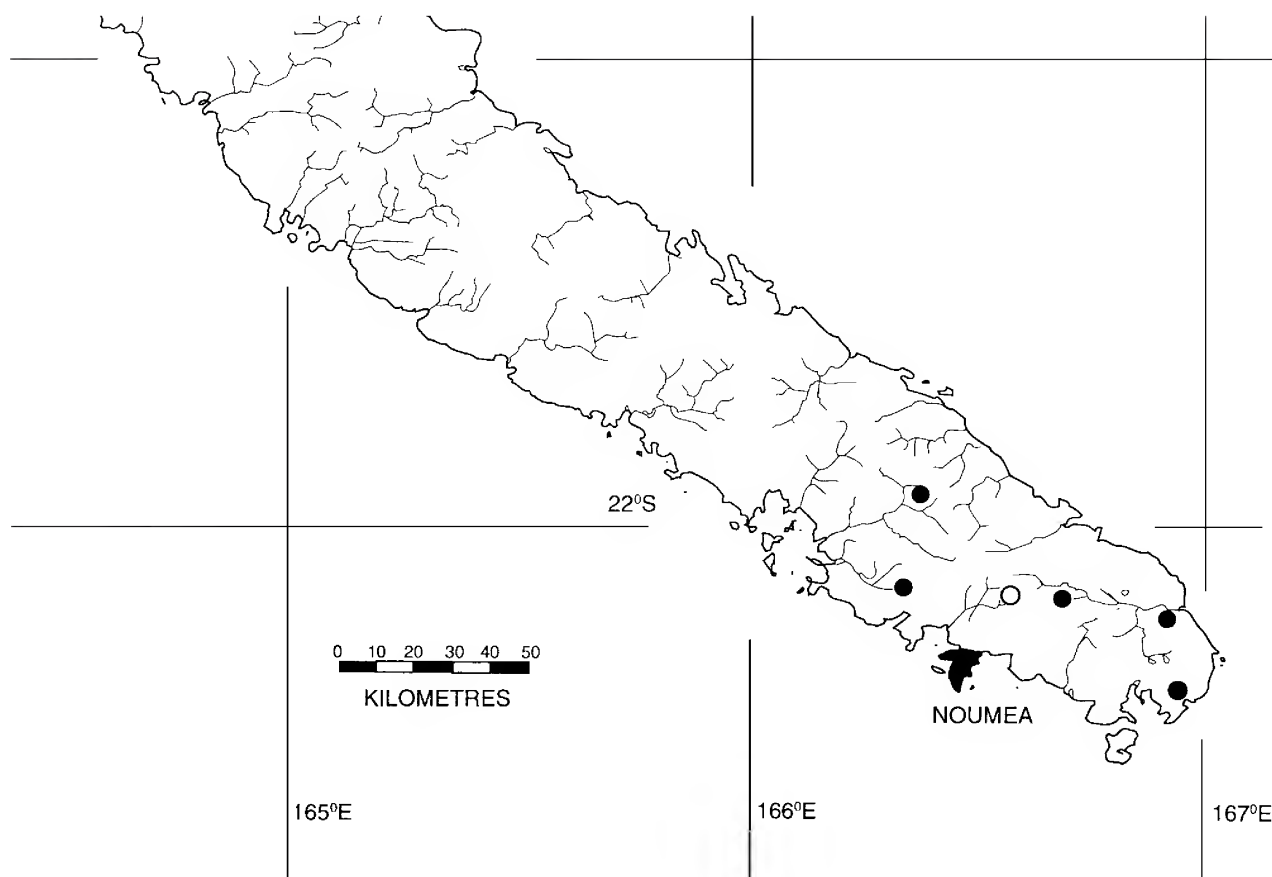
**Osteology.** Premaxillary teeth (adults only) 9 ( $n$  = 4), or 11 ( $n$  = 1); presacral vertebrae 28–29 ( $\bar{x}$  = 28.9,  $SD$  = 0.34,  $n$  = 16); postsacral vertebrae 58–73 ( $\bar{x}$  = 64.9,  $SD$  = 5.52,  $n$  = 7); phalangeal formula for manus and pes

2.3.4.5.3 and 2.3.4.5.4 respectively; two pairs of ribs contacting mesosternum.

**Coloration.** There is sexual dimorphism in colour and pattern between the three adult males and six adult females. Adult females are more obviously two-toned having contrasting light dorsal and dark lateral coloration, and have a pale hip-stripe along the dorsolateral margin which is absent in males.

Adult males (Fig. 1, upper): dorsal surface brown with scattered light and dark markings, lighter in colour overall than females and with the differences in tone between the dorsal and lateral colours not as pronounced as in females. Dorsal markings aligned as in females to resemble obscure dark-edged ocelli. No pale hip stripe along posterior dorsolateral edge. Head a uniform brown above and at the sides. Lateral surface distinct from dorsal surface, two-toned between fore and hindlimbs being black uppermost and





**Figure 2.** Distribution of *Lioscincus tillieri* in New Caledonia, specimen records (●) and observation records (○).

midbrown below with variable pale spotting overall, pale midlateral stripe obscure, most obvious just behind forelimb. Ventral surface in life, bold lemon yellow.

Adult females (Fig. 1, lower): dorsal surface brown (some individuals darker or lighter in tone) and either relatively uniform (smaller adult females) or with variable light and dark markings in which the dark flecks are aligned along the anterior and posterior edge of the pale spots to give the overall appearance of obscure, pale, dark-edged ocelli in the most boldly marked of the females. Posterior dorsolateral edge in region of hindlimbs with a narrow (1 scale width) pale hip stripe, covering the basal portion of the tail and area in front of hindlimbs, poorly expressed in two smaller adult females. Lateral surface dark brown-black, distinct from dorsal, with variable pale spotting uppermost and prominent pale midlateral strip (1 scale width). Ventral surface in life, bold lemon yellow.

**Distribution.** *Lioscincus tillieri* appears to be endemic to maquis habitat in the ultramafic block that covers much of the southern third of the island. Maquis is a heathy formation on ultrabasic rocks, it includes 30% of the native species, 36% of the genera, and 47% of the families occurring in New Caledonia. Ninety-three percent of the species are endemic to New Caledonia (Morat *et al.*, 1986). Within this region (Fig. 2) *L. tillieri* has been recorded from Mt Vulcain

in the north to Kwa Néie in the south. Specimen based records are from Mt Vulcain, Mt Mou, Rivière Bleue, and Yaté, and observations from Montagne des Sources and Kwa Néie. It occurs over a broad altitudinal range from low (200 m asl) to high (1,000 m asl) elevation.

**Biology.** During the course of several visits to New Caledonia observations were made on *Lioscincus tillieri* at Mt Mou (January and September 1995), Mt Vulcain (September 1995), and the type locality of Parc Rivière Bleue (September 1995 and May 1998). The habitat at all three locations is maquis heathland, with notable differences between each site. High elevation maquis at Mt Mou is low and dense with an impenetrable understorey of ferns (Fig. 3). By contrast, the mid to high altitude maquis at Mt Vulcain (700–900 m asl) is low and open (Fig. 4). Low altitude maquis (250 m asl) at Rivière Bleue is well developed and lies adjacent to a forest of *Casuarina* with a dense and tall (1 m) grassy understorey—several *Lioscincus tillieri* were observed at the ecotone between the two habitats.

Both adults and juvenile *Lioscincus tillieri* were observed on the ground amongst shrubs and grasses, and occasionally perched on the groundcover. Clearly arboreal habits were observed on several occasions: an adult male was seen on the trunk of a sapling oriented head down and clearly trying to keep itself pressed flat against the trunk (AMB); one

individual was sighted in a low bush and dropped to the ground when disturbed; and two others not initially seen perching dropped to the ground from a low bush when disturbed. On all occasions *L. tillieri* was wary and difficult to approach. In particular juveniles and subadults observed in elevated positions were only seen briefly before dropping to the ground and seeking shelter. The type specimen of the species was a juvenile collected by entomologists in a malais trap approximately 1 m above the ground.

There are few sheltering sites in maquis habitat. The only specimen of *Lioscincus tillieri* located by searching beneath ground cover was a single individual from Col d'Yaté collected under a stone during overcast and showery weather (A. Whitaker, pers. obs.).

The records of viviparity for the species are from two adult females collected on Mt Mou in January (SVL 60.5 mm and 64 mm) which contain embryos with all scalation features obvious. Three adult females collected in September (SVL 52–55 mm) contained 2–3 large oviductal eggs. This is only the second case of viviparity recorded in the New Caledonian skinks, the other live-bearing species being *Marmorosphax tricolor* (Sadlier, 1986).

**Conservation status.** *Lioscincus tillieri* is known from six locations and under optimal conditions was observed to be moderately common at two of these (Mt Vulcain and Rivière Bleue). For these reasons it is regarded as only moderately restricted in distribution and is not considered to be rare, and would not be regarded as threatened under the current IUCN classification system (1996).

Our field research clearly indicates that *Lioscincus tillieri* is restricted to maquis habitat, and that it inhabits structurally different types of maquis. However, it is not known whether any particular successional stage of maquis is preferred. Consequently the impact of fire and disturbance by mining on maquis habitat are unknown but could be significant and impact on populations of *L. tillieri* at a local level. Field research in the maquis shrublands of the southern ultramafic block is required to clearly establish the species' habitat requirements in order to fully assess the species conservation status.

## Discussion

**Relationships.** *Lioscincus* is an assemblage of generally primitive *Eugongylus* group species from New Caledonia that can not be assigned to any existing monophyletic genus. The species included in the genus possess the following basic suite of derived characters: supranasal scale absent; frontoparietals fused to form a single scale; lower eyelid with a semi-transparent disc; presacral vertebrae 29. *Lioscincus tillieri* clearly possesses a larger suite of apomorphic character states, most notably the presence of two strong keels to the scales of the dorsal surface of the body and tail, and a viviparous mode of reproduction. Its inclusion in *Lioscincus* is considered temporary pending further research on the relationships of these species.

Aside from *Lioscincus tillieri* five other species of New Caledonian skinks have the derived character state of an



Figure 3. Maquis habitat at Mt Mou (800+ m asl).

extremely long tail. Three species of *Tropidoscincus*, the monotypic *Lacertoides pardalis*, and the recently described *Lioscincus maruia*, all have tails as much as 2.5 times longer than the body and an exceptionally high number of postsacral vertebrae, usually 60 or more. It is possible that this common feature is indicative of close relationship between these species. It is also interesting to note that they all inhabit open forest or shrubland habitats, although *Tropidoscincus variabile* and *T. rohssii* also occur in open areas within closed forest habitat.

*Lioscincus tillieri* is most similar to *L. maruia* in body proportions (long-limbed and long-tailed), habits and habitats (surface active species inhabiting maquis shrubland), and certain aspects of scalation (keeled body scales), osteology ( $\bar{x}$  = 58 postsacral vertebrae), and coloration (yellow flush to the ventral surface). However *L. maruia* differs from *L. tillieri* in a number of aspects, most notably in having: weakly tricarinate vs strongly bicarinate body and tail scales; modally 11 vs 9 premaxillary teeth; a single upper secondary temporal scale vs two; and an oviparous vs viviparous mode of reproduction. For these characters the condition described for *L. tillieri* is most likely the apomorphic state. In any case they serve to further diagnose the species and emphasize its uniqueness.



**Figure 4.** Maquis habitat at Mt Vulcain (950 m asl).

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